Technical Guide

How To | Configure VRF-lite

Introduction

In IP-based networks, VRF stands for Virtual Routing and Forwarding. This technology allows multiple routing domains to co-exist within the same device at the same time. As the routing domains are independent, overlapping IP addresses can be used without causing conflict. In large service provider networks, virtual routing and forwarding is used in conjunction with MPLS - Multi Protocol Label Switching - to separate each customer's traffic into its own wide area VPN. VRF is also known as VPN Routing and Forwarding (when used with MPLS), and is also known as Multi-VRF.

What is VRF-lite?

VRF-lite is VRF without the need to run MPLS in the network. VRF-lite is used for isolating customer networks - it allows multiple secure customer routing domains to co-exist in one physical device simultaneously, which remain completely isolated from each other.

VRF-lite also allows the re-use of IP addresses on the same physical device. An IP address range in one VLAN used in one VRF domain can simultaneously be used in another VLAN in a different VRF domain within the same device. While VRF-lite will segregate traffic from different customers/clients, VRF-lite can also allow for route leakage between VRF domains (inter-VRF communication), by using static inter-VRF routes and/or dynamic route leakage via BGP and associated route maps. This provides filtered access from one VRF routing domain to another where the IP address ranges do not overlap.

This How to Note begins with a description of VRF-lite's key features and the generic commands used to configure VRF-lite. There are a number of simple configuration examples provided to illustrate its use with OSPF, RIP, and BGP routing protocols. This is followed with a configuration breakdown of a complex inter-VRF scenario, which includes overlapping IP addresses and a range of routing protocols. Dynamic inter-VRF communication between the global VRF domain and a VRF instance is also explained. Finally, a short list of diagnostics commands are provided to help troubleshoot VRF-related issues.

AlliedWare Plus™ OPERATING SYSTEM

Who should read this document?

This document is aimed at advanced network engineers.

Which products and software version does it apply to?

The information provided in this document applies to:

- SwitchBlade AT-x908 and AT-x900 series switches running 5.4.1 and above.
- x610 switches running AlliedWare+ version 5.4.2 and above.

Note: VRF -lite is not supported in the x600 series switch.

Software feature licenses

The VRF-lite feature requires a special software license. Without a proper license installed, configuring VRFs is not possible. A VRF-lite feature license key is distributed in the Advanced Layer 3 License Bundle that allows up to 8 VRF-lite instances to be configured.

The number of configurable VRF-lite instances can be increased via an additional VRF-lite-63 license.

The Advanced Layer 3 License Bundle containing the VRF-lite feature and the additional VRF-lite-63 license are available through the AW+ licensing web portal (http://licensing.alliedtelesis.com/).

A VRF-lite-63 license requires an Advanced Layer 3 License Bundle to work.

Note: Enabling multiple VRFs means there will be more routing entries on the device system-wide. This may affect the number of routes used by BGP or OSPF specified by the licence key on the device.

Command summary

All the existing CLI commands available in the current non-VRF environment are available with no change.

Contents

Glossary

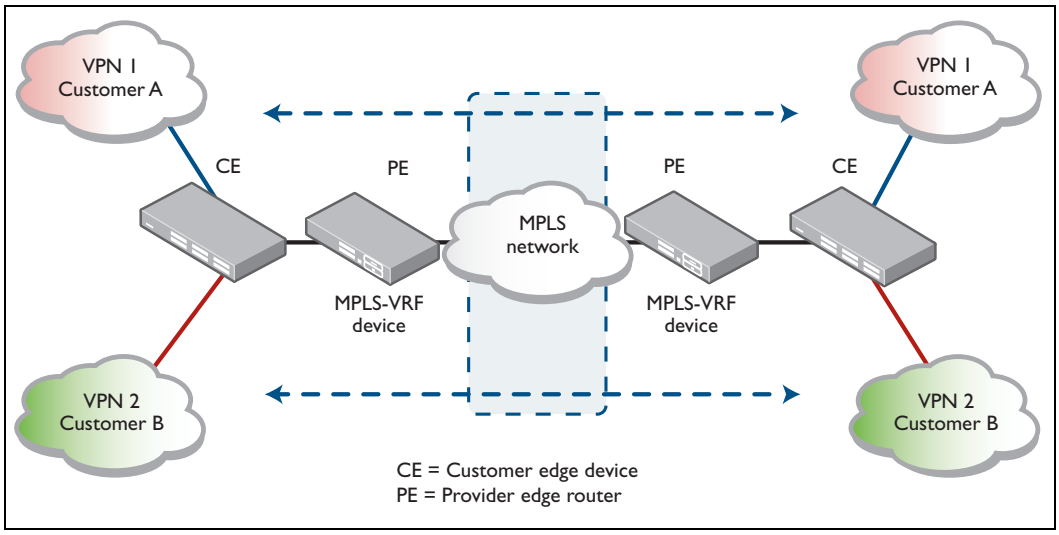
ACRONYM	DESCRIPTION
AS	Autonomous System
ACL	Access Control List
BGP	Border Gateway Protocol
FIB	Forwarding Information Base
MPLS	Multi-Protocol Label Switching
OSPF	Open Shortest Path First
RIP	Routing Information Protocol
VPN	Virtual Private Network
VR	Virtual Router
VRF	Virtual Routing and Forwarding
VRF-lite	VRF without MPLS network
CE	Customer edge
PE	Provider edge
RD	Route Distinguisher
RT	Route Target
VCStack	Virtual Chassis Stacking

Understanding VRF-lite

The purpose of VRF is to enable separate IP networks, possibly using overlapping IP addresses, to share the same links and routers. IP traffic is constrained to a set of separate IP Virtual Private Networks (VPNs). These VPNs provide a secure way for a service provider to carry multiple customers' IP networks across a common infrastructure. The different customers' IP networks are able to operate in complete isolation from each other, so there is no requirement for them to use separate IP address ranges, and there is no leakage of traffic from one VPN to another, unless specifically requested.

A full VRF solution commonly involves different portions of the IP networks being connected to each other by an MPLS backbone network. The separate IP networks will be allocated different tags in the MPLS network. So the full VRF solution involves not only managing multiple separate IP networks within the same routers, but also a network-to-MPLS tag mapping process.

In the full VRF solution a distinction is made between Customer Edge (CE) routers and Provider Edge (PE) routers. CE routers aggregate the separate IP networks of the service provider's different clients. PE routers connect the IP networks to the MPLS backbone.

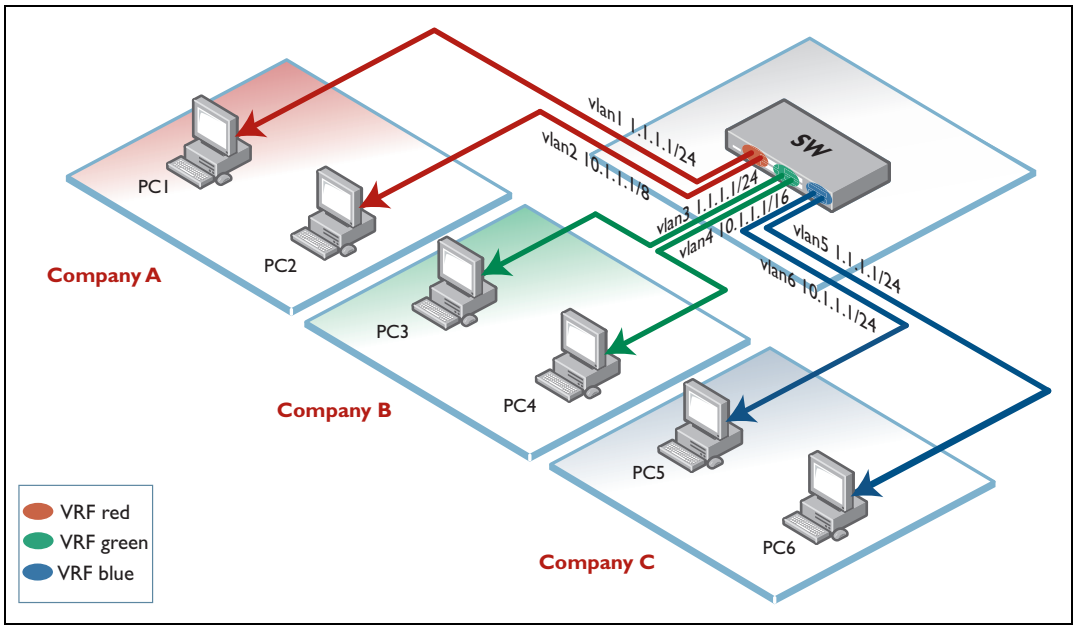


VRF-lite is a subset of the full VRF solution. In a VRF-lite solution there are multiple IP networks sharing the same routers, but no MPLS core is involved. So, VRF-lite is just the customer edge router part of VRF, without the provider edge router part.

VRF-lite facilitates multiple separate routing tables within a single router - one routing table associated with each of the customer VPNs connected to the device. Multiple VRF instances are defined within a router. One or more Layer 3 interfaces (VLAN) are associated with each VRF instance forming an isolated VRF routing domain. A Layer 3 interface cannot belong to more than one VRF instance at any time.

VRF-lite security domains

VRF-lite provides network isolation on a single device at Layer 3. Each VRF domain can use the same or overlapping network addresses, as they have independent routing tables. This separation of the routing tables prevents communication to Layer 3 interfaces in other VRF domains on the same device. Each Layer 3 interface belongs to exactly one VRF instance and traffic between two Layer 3 interfaces on the same VRF instance is allowed as normal. But by default, interfaces in other VRF instances are not reachable as no route exits between the interfaces unless explicitly configured via Inter-VRF routing.



For example, on a device three VRF instances (VRF red, VRF green and VRF blue) are configured for three different companies. Devices PC1 and PC2 from Company A can communicate normally within the confines of VRF red, but none of PC1's and PC2's traffic can be seen by other devices in VRF green and VRF blue.

Route table and interface management with VRF-lite

A key feature that VRF-lite introduces to a router is the existence of multiple IP route tables within the one router.

By default, before any VRF is configured, a router will have one route table, and routes via all IP interfaces of the router will be stored in this one table. As VRF instances are configured on the router, the original route table remains. This default route table, and its associated IP interfaces, are then referred to as the default global VRF domain.

Interface management with VRF

Each network interface can belong to only one VRF. As mentioned above, initially every interface is in the default global VRF domain. As Layer 3 interfaces are moved to the created VRF instances, they are removed from the global VRF domain, so the global VRF domain manages a decreasing set of Layer 3 interfaces.

When a Layer 3 interface is moved to a VRF instance from the default global VRF domain, or when a Layer 3 interface is moved from one VRF instance to another via command, the interface name and id (ifindex) are never changed as a result of the interface movement. However IP configuration on the interface in the previous VRF is unset (removed) before moving the interface to a new VRF.

ARP entries associated with the Layer 3 interface are cleared when the interface is moved from one VRF instance to another. In addition (static and dynamic) ARP entries are VRF aware, as the same IP address can be used in other VRF instances.

Adding a VRF-aware static ARP

```
awplus(config)#arp ?
  A.B.C.D  IP address of the ARP entry
  log      Arp log
  vrf      VRF instance

awplus(config)#arp vrf <name> ?
  A.B.C.D  IP address of the ARP entry
```

Route management with VRF

- Each VRF instance maintains its own IPv4 routing table independent from the routing table of the global VRF domain or other VRFs.
- Routing entries can be added statically by user command or dynamically by a routing protocol module such as BGP, OSPF, or RIP within the VRF instance. Use of a dynamic routing protocol allows for each VRF network to maintain a consistent routing table across all the devices within the VRF network.
- The way that each routing is able to define a separate instance of itself on multiple VRF instances varies from protocol to protocol:
  - For BGP, one BGP routing instance will be running for an Autonomous System in the global VRF domain and individual BGP routing tables will be managed per VRF by using the address-family feature. One address-family is created for each VRF instance.
  - For OSPF, one OSPF routing instance is configurable per VRF, and one OSPF instance is configurable within the global VRF domain.
  - For RIP, one RIP routing instance will be running in the default global VRF domain and individual RIP routing tables will be managed per VRF by using the address-family feature. One address-family is created for each VRF instance.

Note: The command **show ip route** displays the routes associated with each VRF instance.

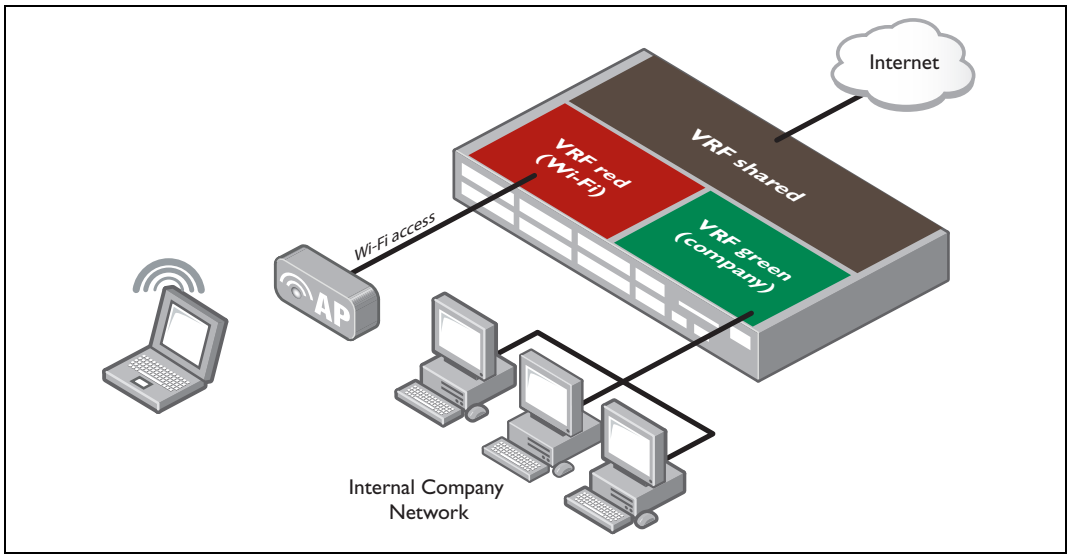
Inter-VRF communication

Whilst the prime purpose of VRF-lite is to keep routing domains separate from each other, there are cases where you do want some communication between VRFs.

An example to consider is multiple 'clients' requiring shared Internet access. In this case a VRF instance can be created for each, providing secure and separate routing. Whilst overlapping IP addresses could be used with this scenario, only one instance of each overlapping address range will be able to access the Internet for the simple reason that when return traffic comes back from the Internet to an address in one of the overlapped subnets, the VRF aware device must have only one choice for which instance of that subnet to send that return traffic to.

A distinct shared VRF is utilised to allow sharing of the Internet connection. The shared VRF is actually just another VRF instance; it has no special VRF properties.

In the example below, each of the red and green VRFs need inter-VRF communication with the shared VRF. This is achieved by selectively leaking routes between the shared VRF and the other two VRFs, and vice-versa. The selective leaking can use statically configured routes or dynamic route import/export via the BGP protocol.



For example, a company may wish to segregate their network and provide Wi-Fi access to the Internet for visitors to the company, whilst preventing the visitors from accessing the internal company network. The users in internal company network and visitors in the Wi-Fi network are able to share a single common Internet connection.

Internal company and Wi-Fi networks are isolated in Layer 3 on the same device by using different VRFs, but they want to access the Internet by using the same network interface on VRF shared. To make it work with dynamic route import/export, VRF green (company VRF) needs to import routes from VRF shared to access the Internet and some selected routes from VRF green need to be exported to VRF shared. Similar configuration is needed for VRF red (Wi-Fi VRF) for importing/exporting routes between VRF red and VRF shared.

As a result traffic flows between VRF green and VRF shared and between VRF red and VRF shared but not between VRF green and VRF red.

Static and dynamic inter-VRF routing

As mentioned above, "Inter-VRF communication" on page 8, in some circumstances it is required to (selectively) allow traffic between two interfaces that are not in the same VRF. This will be useful if there is common network equipment (e.g. Internet connections or shared resources) that multiple VRFs need to share.

Inter-VRF routing is achieved by statically or dynamically taking a route entry and its next-hop interface from one VRF, and adding it into the routing table of another. A dynamic inter-VRF route can be added by using the BGP route import/export feature. A static inter-VRF route can be added by a user command. For more information on static routing, see "Static inter-VRF routing" on page 17.

Static and dynamic inter-VRF communication can be used simultaneously or separately. Dynamic inter-VRF communication is only achieved via use of the BGP routing protocol. OSPF and RIP cannot be used to achieve inter-VRF communication.

Internally transferring routes between VRF instances is quite separate from the sharing of routes of a specific VRF routing domain, with external routers that are members of that same domain. As mentioned above, all dynamic routing protocols can be used to distribute routing information to external peer devices. OSPF, RIP, and BGP can all be used to dynamically distribute routes to external peers within VRF routing domains.

When BGP is used for dynamic inter-VRF communication, routes from other routing protocols (including connected routes, static routes, OSPF or RIP) are redistributed into a VRF instance's BGP route table (BGP must be configured and associated with the VRF instance). Other VRF instances that are configured with BGP can selectively copy these routes into their own separate BGP route tables.

Inter-VRF route leakage interoperates with the exchange of route information. Routes learnt from external peers in one VRF domain can be leaked to other VRF instances and routes leaked into a VRF instance can then be advertised to external peers connected to that instance.

The details of dynamic inter-VRF routing are described in "Dynamic inter-VRF communication explained" on page 18.

VRF-lite features in AW+

Here is a summary of the features provided by the AW+ VRF-lite implementation:

- Multiple independent routing table instances may co-exist within the same device. The same or overlapping IP addresses can be present in different route table instances without conflicting. All routing table instances remain securely isolated from those existing in other routing tables.
- By default, no communication occurs between VRF instances, facilitating multiple secure routing domains within the same VRF aware device.

  However, **inter-VRF** communication between routing domains is possible by using either static inter-VRF routes and/or dynamic filtered route leakage via BGP and its associated route maps.
- A single device configuration file simplifies management by providing the ability to create, manage, and monitor all VRF instances.
- Detailed diagnostic and debugging information is available.
  - Ability to view routing table information per VRF.
  - All appropriate VRF related information and error messages can be viewed in the system wide log.
- Separate instances of routing protocols can be mapped to VRF instances so that distribution of route information can be performed on a per VRF domain basis. This enables route information to be distributed securely within each VRF routing domain.

  For example:

  VRF1 = OSPF routing instance1

  VRF2 = OSPF routing instance2
- All Layer 3 interfaces and associated switch ports remain in the default global VRF domain until associated with a specific VRF instance.
- VRF is supported in HW and SW (including Inter-VRF communications).
- The default global VRF domain always exists and cannot be removed. Initially during startup, every VLAN belongs to the default global VRF domain. Also, when a VLAN is removed from a VRF, it is automatically returned to the default global VRF domain. Only one default global VRF domain exists in each physical device.
- Static and dynamic routes can be leaked from a VRF instance to the global default VRF.
- Selected routes within a VRF instance can be dynamically leaked to other VRF routing domains. This applies both to routes that have been statically configured, and to routes that have been learnt into a VRF instance on the device by routing protocol exchanges with external peer routers.
- When a VRF instance has received routes leaked from other VRF instances, that instance can advertise those routes to external peer routers connected to interfaces in that VRF instance, via the routing protocol operating within the VRF instance.

Route limiting per VRF instance

In a multi-VRF network environment, it may be problematic if one VRF injects too many routes and fills up the hardware forwarding table (FIB) on the device, which can affect other VRFs as well as the global VRF. For more information see "Route Limits" on page 84

VRF-aware utilities within AW+

Some network utility and management features such as ping, traceroute, telnet client, SSH client, and tcpdump are supported in a VRF aware manner.

VRF aware services include

- Ping

```
awplus#ping ?
  WORD  Ping destination address or hostname
  ip    IP echo
  ipv6  IPv6 echo
  vrf   VRF instance (source VRF)
  <cr>

awplus#ping vrf <name> ?
  WORD  Ping destination address or hostname
  ip    IP echo

awplus#ping vrf <name> x.x.x.x

awplus#ping vrf <name> x.x.x.x ?
  broadcast  Ping to a broadcast address
  df-bit     Enable do-not-fragment bit in IP header
  interval   Specify interval between pings
  pattern    Specify data pattern
  repeat     Specify repeat count
  size       Specify datagram size
  source     Specify source address or interface name
  timeout    Specify timeout interval
  tos        Specify type of service
  <cr>
```

- Trace route

```
awplus#traceroute ?
  WORD  Trace route to destination address or hostname
  ip    IP Trace
  ipv6  IPv6 trace
  vrf   VRF instance
  <cr>

awplus#traceroute vrf <name> ?
  WORD  Trace route to destination address or hostname
  ip    IP Trace

awplus#traceroute vrf <name> x.x.x.x
```

- Telnet client

```
awplus#telnet ?
  WORD  IPv4/IPv6 address or hostname of a remote system
  ip    IP telnet
  ipv6  IPv6 telnet
  vrf   VRF instance

awplus#telnet vrf <name> ?
  WORD  IPv4 address or hostname of a remote system
  ip    IP telnet

awplus#telnet vrf <name> ip x.x.x.x
```

- SSH client

```
awplus#ssh ?
  HOSTNAME  IP/IPv6 address or hostname of a remote server
  client    Configure global SSH client parameters
  ip        IP SSH
  ipv6      IPv6 SSH
  port      SSH server port
  user      Login user
  version   SSH client version
  vrf       VRF instance

awplus#ssh vrf <name> ?
  HOSTNAME  IP/IPv6 address or hostname of a remote server
  ip        IP SSH
  port      SSH server port
  user      Login user
  version   SSH client version

awplus#ssh vrf <name> x.x.x.x
```

- TCP dump

```
awplus#tcpdump ?
  LINE  Execute tcpdump
  vrf   VRF instance
  <cr>

awplus#tcpdump vrf <name> ?
  LINE  Execute tcpdump
  <cr>

awplus#tcpdump vrf <name>
```

In this VRF-lite implementation, other Layer 4+ services and applications are not supported on a per-VRF basis - such as Telnet server, SSH server, file copy, system log, SNMP server, DHCP server, DHCP relay, NTP server, etc. However, these services will remain supported in the global VRF domain context, which is same as in a non-VRF environment.

Configuring VRF-lite

The following section describes the generic commands used to configure VRF-lite.

CONFIGURING ACLS		PURPOSE
Step 1	`awplus# conf t`	Enter Global Configuration mode.
Step 2	`awplus(config)# access-list standard <access-list-name> {deny|permit}<network>`	
CONFIGURING VRFS		**PURPOSE**
Step 1	`awplus(config)#ip vrf <vrf-name> <lo-interface-number>`	Create a named Virtual Router Forwarding (VRF) instance. If the optional Local Interface (LO) parameter not specified, a local interface is automatically created and associated with the VRF instance. If the LO parameter is specified, it allows the user to control which LO is associated with a particular VRF instance.
Step 2	`awplus(config-vrf)#rd <route distinguisher>`	
Step 3	`awplus(config-vrf)#route-target export <ASN>`	Optional. Exports routes from the VRF instance to BGP.
Step 4	`awplus(config-vrf)#route-target import <ASN>`	
Step 5	`awplus(config-vrf)#import map <route-map-name>`	Optional. Configure an import map, which references a route map, and associated ACL. Used to selectively import routes into the VRF instance from BGP.
Step 6	`awplus(config-vrf)#export map <route-map-name>`	
Step 7	`awplus(config-vrf)#exit`	Return to Global Configuration mode.

CONFIGURING VLANS AND VLAN DATABASE		PURPOSE
Step 1	`awplus(config)#vlan database`	VLANs are created in the VLAN database, and ports are assigned to relevant VLANs.
Step 2	`awplus(config-vlan)#vlan x state enable`	
Step 3	`awplus(config-vlan)#exit`	
Step 4	`awplus(config)#interface portx.x.x`	
Step 5	`awplus(config-if)#switchport access vlanx`	
Step 6	`awplus(config-if)#exit`	

CONFIGURING LOCAL LOOPBACK IP INTERFACE		PURPOSE
Step 1	`awplus(config-if)#interface lo1`	
Step 2	`awplus(config-if)#ip address x.x.x.x/x`	Optional - IP network is associated with the LO interface, to be used by upper layer routing protocols.
Step 3	`awplus(config-if)#exit`	

CONFIGURING VLANS - IP AND VRF MEMBERSHIP		PURPOSE
Step 1	`awplus(config)#interface <vlan-name>`	VRF routing domains are formed by associating a VLAN Layer 3 interface with a VRF instance.
Step 2	`awplus(config-if)#ip vrf forwarding <vrf-name>`	<name>is the name of a VRF instance created by the IP VRF <name> command.
Step 3	`awplus(config-if)#ip address <subnet>`	
Step 4	`awplus(config-if)#exit`	

DYNAMIC ROUTING PROTOCOL - OSPF INSTANCE		PURPOSE
Step 1	`awplus(config)#router osfp <1-65535> <vrf-name>`	Optional. Associate an OSPF routing instance with a specific VRF instance, and enter router configuration mode.
Step 2	`awplus(config-router)#network <x.x.x.x/x> area <area-id>`	Define a network on which the OSPF instance runs and the area ID for that network.
Step 3	`awplus(config-router)#redistribute <protocol>`	Configure the device to redistribute information from another routing protocol into OSPF. For example BGP can be specified, to allow OSPF to advertise inter-VRF routes to an OSPF peer.
Step 4	`awplus(config-router)#exit`	

DYNAMIC ROUTING PROTOCOL - RIP ADDRESS-FAMILY		PURPOSE
Step 1	`awplus(config)#router rip`	Optional. Enter router configuration mode for RIP.
Step 2	`awplus(config-router)#address-family ipv4 vrf <vrf-name>`	Associate a RIP address-family with a specific VRF instance.
Step 3	`awplus(config-router-af)#network x.x.x.x/x`	Define a network on which the RIP address-family runs.
Step 4	`awplus(config-router-af)#redistribute <protocol>`	Configure the device to redistribute information from another routing protocol into the RIP address-family. For example BGP can be specified, to allow RIP to advertise inter-VRF routes to a RIP neighbor.
Step 5	`awplus(config-router)#exit-address-family`	
Step 6	`awplus(config-router)#exit`	

DYNAMIC ROUTING PROTOCOL - BGP ADDRESS-FAMILY		PURPOSE
Step 1	`awplus(config)#router bgp <ASN>`	Mandatory if BGP is used for inter-VRF communications. Not required if static inter-VRF routes are used instead of BGP to provide inter-VRF communications. Enter router configuration mode for BGP and assign the BGP ASN. Define a single BGP ASN for the device. Multiple ASNs not supported.
Step 2	`awplus(config-router)#address-family ipv4 vrf <vrf-name>`	Associate a BGP address-family with a specific VRF instance.
Step 3	`awplus(config-router-af)#redistribute <protocol>`	Configure the device to redistribute information from another routing protocol into the BGP address-family. For example 1) connected, or static can be specified, to allow BGP to advertise connected or static routes to BGP neighbor - if external BGP neighbor is configured. 2) Ensure the connected or static routes are redistributed into BGP to be used for inter-VRF communications.
Step 4	`awplus(config-router-af)#neighbor x.x.x.x <remote-ASN>`	If required, define a BGP neighbor and its associated ASN.
Step 5	`awplus(config-router-af)#neighbor x.x.x.x activate`	Activate the BGP neighbor to allow the BGP Transport Layer TCP connection to establish to the specified BGP neighbor.
Step 6	`awplus(config-router-af)#exit-address-family`	
Step 7	`awplus(config-router)#exit`	

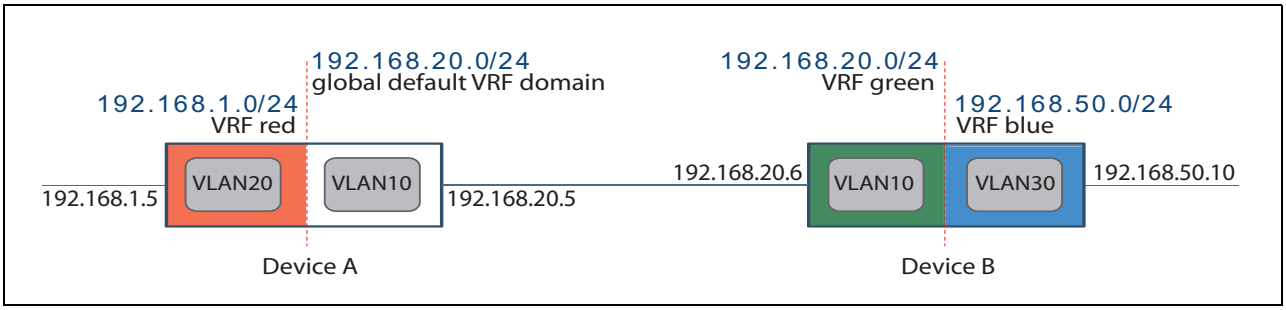
STATIC ROUTES		PURPOSE
Step 1	`awplus(config)# ip route vrf <name> <network> {<gateway> <interface>| <interface>}`	Optional. To add a static route into the Routing table for a VRF instance. This can be a route pointing externally to a nexthop reachable via an interface in this VRF instance, or it can be used to facilitate inter-VRF routing, in which case it would point to an interface in a different VRF instance. Static inter-VRF routes can be used instead of BGP, or in conjunction with BGP to provide inter-VRF communications.

ROUTE MAPS THAT REFERENCE ACLS AND VRFS		PURPOSE
Step 1	`awplus(config)#route-map word (deny| permit) <1-65535>`	Optional. Configure a route map name that is referenced by a VRF import or export map.
Step 2	`awplus(config-route-map)#match ip address <ACL name>`	Configure a route map entry which references an ACL.
Step 3	`awplus(config-route-map)#exit`	
Step 4	`awplus(config)#exit`	

Static inter-VRF routing

Static inter-VRF routing involves creating static routes in one VRF instance whose egress VLAN is in a different egress VLAN. These static routes must specify both the egress VLAN and next hop IP address.

The following diagram illustrates use of static routing to achieve inter- VRF communication in VRF-lite.



DEVICE A STATIC ROUTES CONFIGURATION	DEVICE B STATIC ROUTES CONFIGURATION
ip route vrf red 192.168.20.0/24 vlan10 From source vrf red, create a static route to 192.168.20.0/24 to access target vlan10. Target vlan is required when performing static IVR.	**ip route vrf blue 192.168.20.0/24 vlan10** From source vrf blue, create a static route to 192.168.20.0/24 to access target vlan10. Target vlan is required when performing static IVR.
ip route 192.168.1.0/24 vlan20 From the source global VRF domain, create a static route to 192.168.1.0/24 to access target vlan20. Target vlan is required when performing static IVR.	**ip route vrf green 192.168.50.0/24 vlan30** From the source vrf green, create a static route to 192.168.50.0/24 to access target vlan30. Target vlan is required when performing static IVR.
ip route vrf red 192.168.50.0/24 192.168.20.6 vlan10 From source vrf red, create a static route to 192.168.50.0/24 with a next hop of 192.168.20.6 egressing target vlan10. Target vlan is required when performing static IVR.	**ip route vrf blue 192.168.1.0/24 192.168.20.5 vlan10** From source vrf blue, create a static route to 192.168.1.0/24 with a next hop of 192.168.20.5 egressing target vlan10. Target vlan is required when performing static IVR.
ip route 192.168.50.0/24 192.168.20.6 From the global VRF domain, create a static route to 192.168.50.0/24 with a next hop of 192.168.20.6. Static routes to networks within a VRF instance do not require target vlan.	**ip route vrf green 192.168.1.0/24 192.168.20.5** From the source vrf green, create a static route to 192.168.1.0/24 with a next hop of 192.168.20.5. Static routes to networks within a VRF instance do not require the target vlan.

Dynamic inter-VRF communication explained

The following section explains how VRF routing domain isolation is maintained, and how routes that exist in one VRF instance are leaked to another VRF instance via BGP. Only BGP can be used to dynamically leak routes from one VRF instance to another.

The Forwarding Information Base (FIB) and routing protocols

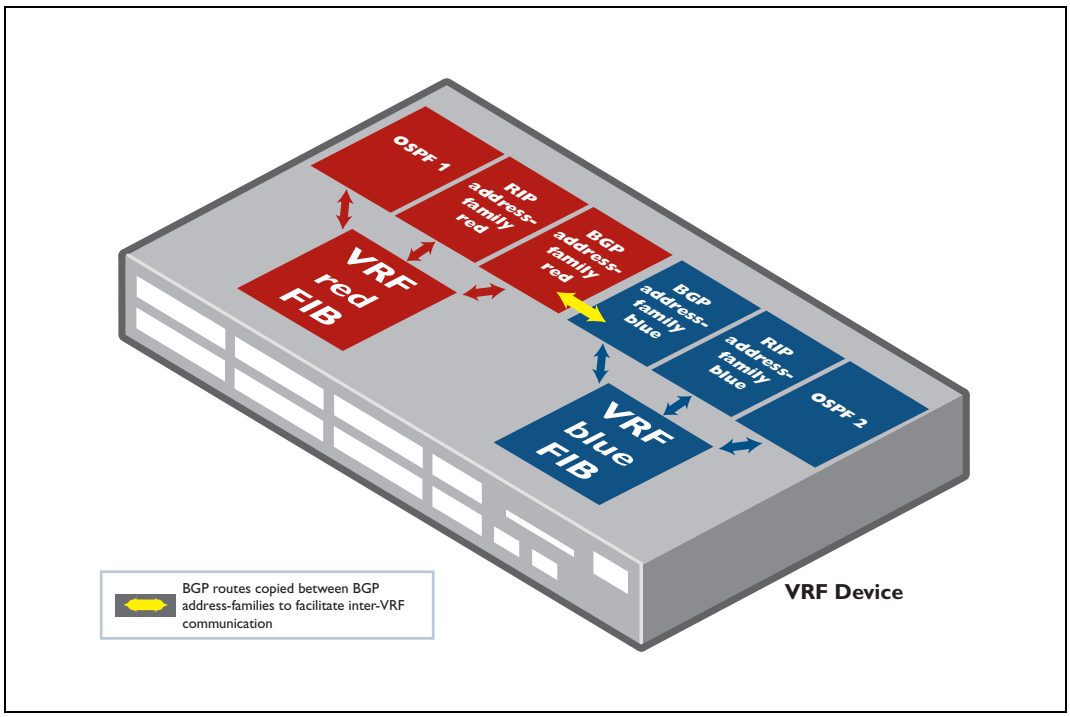
Associated with each VRF instance is an IP route table, also known as the Forwarding Information Base (FIB). When BGP address-families (associated with VRF instances) are configured, a corresponding BGP route table is created for each VRF instance on which a BGP address-family is configured.

Similarly, when RIP address-families (associated with VRF instances) are configured, a corresponding RIP route table is created for each VRF instance on which a RIP address-family is configured.

Similarly, when OSPF instances (associated with VRF instances) are configured, a corresponding OSPF route table is created for each VRF instance on which an OSPF instance is configured.

Each dynamic routing protocol **automatically** selects appropriate routes and copies them to the FIB.

Static and connected routes are automatically added to the FIB when they are created.



The command **redistribute <protocol>** can be configured in an OSPF instance, BGP address-family, or RIP address-family. Via this command, routes are imported from the FIB associated with the VRF instance into the dynamic routing protocol table. Any routing protocol (OSPF, BGP, RIP static, connected, etc.) can be redistributed.

- For example, if OSPF instance1 is configured on VRF red, and if OSPF 1 contains the command **redistribute BGP**, then BGP routes will be copied from VRF red FIB to OSPF instance1.
- Similarly, if BGP address-family is configured on VRF red, and if the address-family contains the command **redistribute OSPF**, then OSPF instance1 routes will be copied from the VRF red FIB into the BGP red address-family route table.

Dual role of BGP

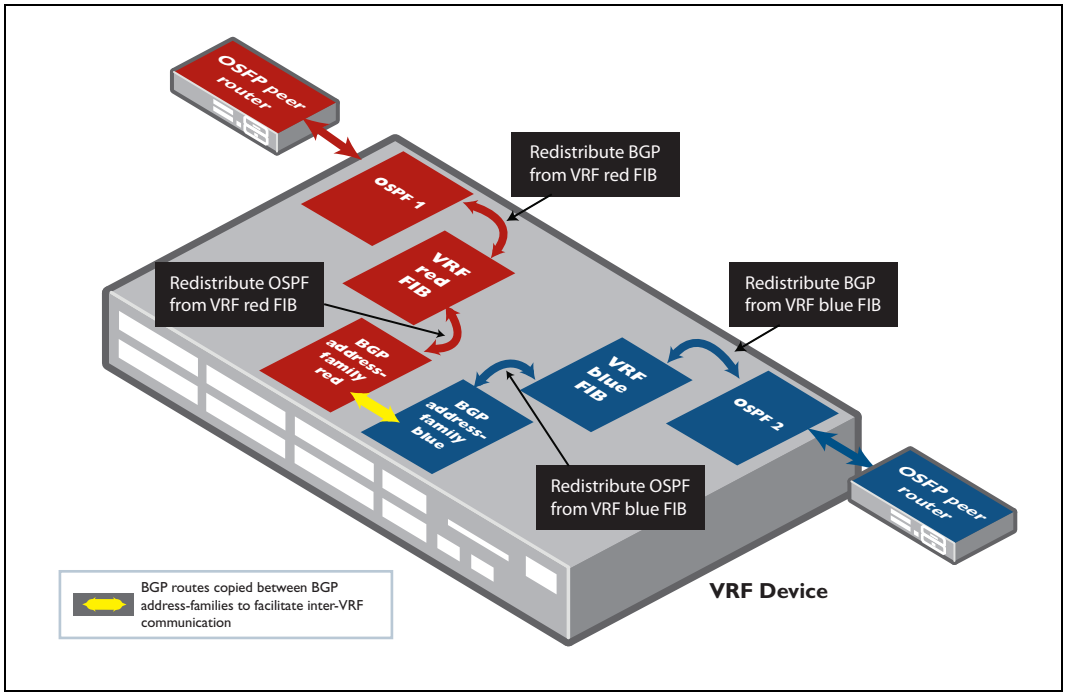
The **first** role that BGP plays in a VRF-lite environment is to facilitate BGP peering to an external router operating **within** the VRF routing domain via the **neighbor x.x.x.x** command configured in a BGP address-family.

The **second** role that BGP plays is to facilitate route leakage **between** VRF routing domains.

Dynamic routing protocols (RIP and OSPF) do not facilitate route leakage. RIP and OSPF only operate within a VRF routing domain.

Inter-VRF communication via BGP

Dynamic inter-VRF route leakage is achieved by making copies of BGP routes that exist in one BGP address-family associated with one VRF instance, to another BGP address-family associated with a different VRF instance.



In the diagram above, the following is configured:

- OSPF1 is configured in VRF-red, and OSPF1 contains **redistribute BGP**
- OSPF2 is configured in VRF-blue, and OSPF2 contains redistribute BGP
- BGP is configured and contains BGP address-families red and blue
- Both BGP address-families contain redistribute OSPF

Then route leakage of routes from VRF red to VRF blue occurs as follows:

1. OSPF1 selects appropriate OSPF routes learned from external VRF red OSPF peer and automatically adds them to red FIB route table.
2. OSPF1 routes are imported from red FIB route table into BGP address-family red BGP route table (via the BGP **redistribute OSPF** command).
3. Via the **route-target import** command, BGP address-family red BGP routes are selected and copied into BGP address-family blue BGP route table.
4. Appropriate BGP address-family blue BGP routes are selected and automatically added to the VRF blue FIB route table.
5. OSPF2 then imports and redistributes the BGP routes (learned originally from VRF red OSPF peer) into OSPF2 from VRF blue FIB route table (via OSPF **redistribute BGP** command).
6. Those OSPF routes are then advertised to external VRF blue OSPF peer.

And the same process is used to leak routes from VRF blue to VRF red.

Using the route-target command

When BGP is used for inter-VRF communication, dynamic route leakage of BGP routes from one VRF instance to another is achieved via the VRF **route-target** command.

There are three variations of the route-target command:

1. route-target export <ASN:VRFinstance>

   for example:

```
ip vrf red
 rd 100:1
 route-target export 100:1
```

2. route-target import <ASN:VRFinstance>

   for example:

```
ip vrf red
 rd 100:1
 route-target import 100:2
```

3. route-target both <ASN:VRFinstance>*

   for example:

```
ip vrf red
 rd 100:1
 route-target export 100:1
 route-target export 100:2
 route-target export 100:3
 route-target import 100:2
```

   can be replaced with:

```
ip vrf red
 rd 100:1
 route-target export 100:1
 route-target export 100:3
 route-target both 100:2
```

*Use of the command **route-target both** is uncommon in a VRF-lite environment.

The command **route-target export** applies a BGP extended community attribute to each BGP prefix stored in the BGP route table of the address-family associated with the VRF instance. The content of this attribute is the (ASN) that was specified in the **route-target export** command.

The following three examples demonstrate how the **route-target** command facilitates inter-VRF communication:

1. If VRF red configuration includes:

```
ip vrf red
 rd 100:1
 route-target export 100:1
```

And if VRF red initially has routes to networks 10.0.0.0/24, 20.0.0.0/24, then the entries in the address-family red BGP route table for each of those two routes would have the extended-community attribute applied as follows:

```
10.0.0.0/24 100:1
20.0.0.0/24 100:1
```

Also, if VRF shared configuration includes:

```
ip vrf shared
 rd 100:2
 route-target import 100:1
```

then VRF shared will check all other VRFs' BGP tables searching for routes with the extended-community attribute 100:1, and those specific routes will be copied into the VRF shared BGP route table from the other VRFs, and they will be marked as copied BGP routes.

VRF shared will then have copied BGP routes that have been leaked from VRF red:

```
(copy)10.0.0.0/24 100:1
(copy)20.0.0.0/24 100:1
```

2. If VRF red initially includes:

```
ip vrf red
 rd 100:1
 route-target export 100:1
 route-target import 100:2
 10.0.0.0/24 100:1
 20.0.0.0/24 100:1
```

And if VRF shared initially includes:

```
ip vrf shared
 rd 100:2
 route-target export 100:2
 route-target import 100:1
 30.0.0.0/24 100:2
 40.0.0.0/24 100:2
```

Then via BGP inter-VRF routing (IVR), VRF red will end up with the routes:

```
10.0.0.0/24 100:1
20.0.0.0/24 100:1
(copy)30.0.0.0/24 100:2
(copy)40.0.0.0/24 100:2
```

And via BGP IVR, VRF shared will end up with the routes:

```
(copy)10.0.0.0/24 100:1
(copy)20.0.0.0/24 100:1
30.0.0.0/24 100:2
40.0.0.0/24 100:2
```

Each VRF instance now contains dynamic inter-VRF routes.

3. If VRF red configuration includes*:

```
ip vrf red
 rd 100:1
 route-target export 100:1
 route-target export 100:2
 route-target export 100:3
 route-target export 100:4
 route-target import 100:5
 route-target import 100:6
```

And if VRF red initially has routes to networks 10.0.0.0/24, 20.0.0.0/24, then each of those two routes would have multiple extended community attributes (as defined in the **route-target export** command configured in the VRF instance) as follows:

```
10.0.0.0/24 100:1 100:2 100:3 100:4
20.0.0.0/24 100:1 100:2 100:3 100:4
```

And If VRF shared configuration includes:

```
ip vrf shared
 rd 100:5
 route-target export 100:5
 route-target import 100:2
```

And if VRF shared initially has routes to networks 30.0.0.0/24, 40.0.0.0/24, then each of those two routes would have an extended community attribute applied (as defined in the **route-target export** command) as follows:

```
30.0.0.0/24 100:5
40.0.0.0/24 100:5
```

Then via BGP IVR, VRF red will end up with the routes:

```
10.0.0.0/24 100:1 100:2 100:3 100:4
20.0.0.0/24 100:1 100:2 100:3 100:4
(copy)30.0.0.0/24 100:5
(copy)40.0.0.0/24 100:5
```

And via BGP IVR, VRF shared will end up with the routes:

```
(copy)10.0.0.0/24 100:1 100:2 100:3 100:4
(copy)20.0.0.0/24 100:1 100:2 100:3 100:4
30.0.0.0/24 100:5
40.0.0.0/24 100:5
```

*Use of the command **route-target export**, as per example 3 above, to tag routes in a VRF instance with ASNs associated with other VRF instances is uncommon in a VRF-lite environment.

How VRF-lite security is maintained

Incidentally, only the original routes can be copied from one VRF to another. Copied routes cannot be subsequently copied to another VRF, to ensure VRF security domains are enforced.

For example:

VRFred----VRFshared----VRFgreen

If VRF red routes are copied into the route table of VRF shared, VRF red routes will not be able to subsequently be copied from VRF shared into the VRF green route table. This ensures that while VRF green, and VRF red can access VRF shared, there is no inter-VRF communication between VRF red and VRF green - unless additional route leakage is configured.

Similarly, routes learnt by the default global VRF domain from a VRF instance via internal BGP peering cannot be subsequently advertised from the default global VRF domain to another VRF instance.

VRFred---default_global_VRF---VRFgreen

Viewing source VRF and attribute information for a prefix

The command **show ip bgp < prefix>** can be used to display source VRF and extended community attribute information for a route.

For example:

```
VRF_device#show ip bgp 192.168.120.0

[VRF: green]
BGP routing table entry for 192.168.120.0/24
Paths: (1 available, best #1, table Default-IP-Routing-Table)
  Not advertised to any peer

    192.168.20.1 from 192.168.20.10 (192.168.20.10)
      Origin IGP metric 0, localpref 100, valid, external, best
      Extended Community: RT:500:2
      Last update: Thu Nov 18 03:51:06 2010


[VRF: common]
BGP routing table entry for 192.168.120.0/24
Paths: (1 available, best #1, table Default-IP-Routing-Table)
  Not advertised to any peer

    192.168.20.1 from 192.168.20.10 (192.168.20.10)
      Origin IGP metric 0, localpref 100, valid, external, best
      Extended Community: RT:500:2
      Copied from VRF: green
      Last update: Thu Nov 18 03:51:06 2010
```

Simple VRF-lite configuration examples

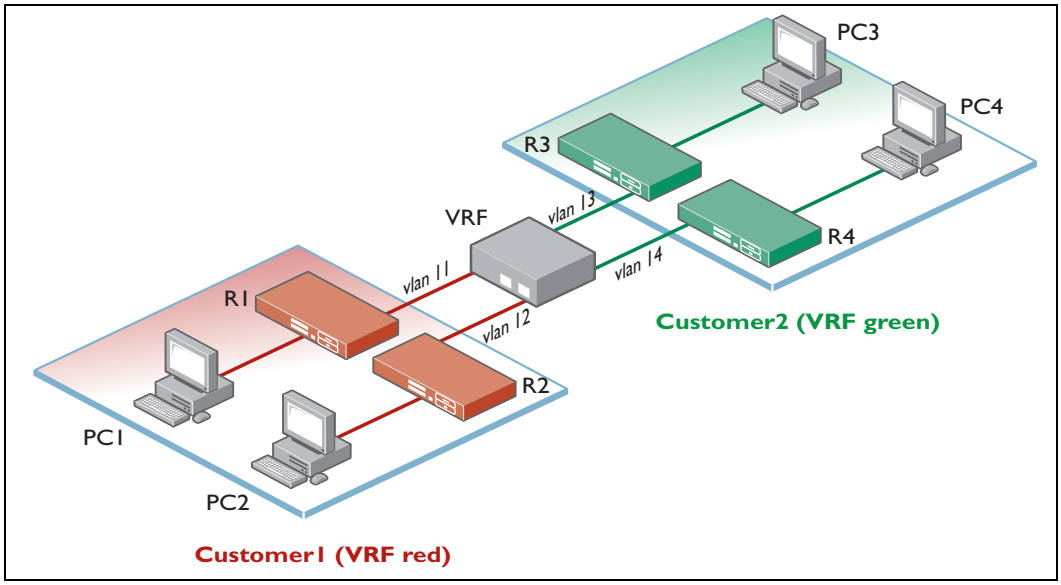
The following section contains simple configuration examples to explain the basics of VRF-lite configuration used in conjunction with a variety of routing protocols.

Firstly, always create a clear VRF communication plan. This includes researching the various routing protocols and likely IP network plans for each VRF, and the likely content of each VRF routing table. Also confirm any overlapping IP address space requirements, and if there are any inter-VRF communication requirements.

Multiple VRFs without inter-VRF communication

The partial configuration example below shows the key components required to support multiple VRF instances with OSPF peering to external neighbors within each VRF instance. There is no inter-VRF communication used in this first example.

Two interfaces, vlan11 and vlan12 are configured for Customer1 (VRF red), and two other interfaces, vlan13 and vlan14 are configured for Customer2 (VRF green). In this example, overlapping IP addresses are used. OSPF is used as the routing protocol within each VRF instance.



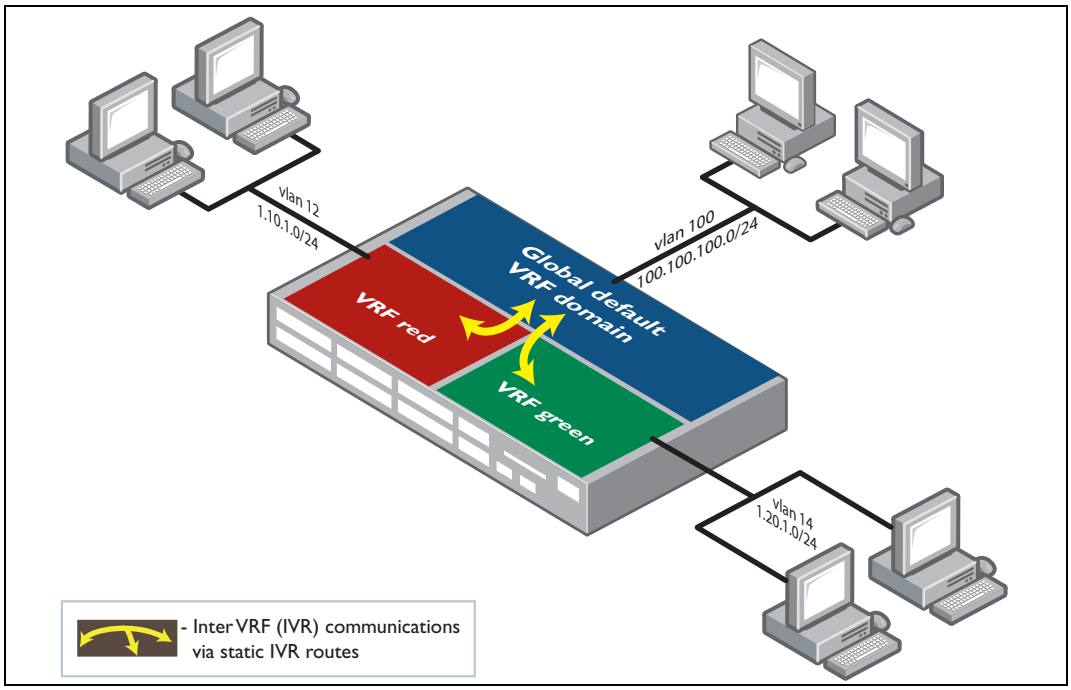

```
...
!
ip vrf red
 description Customer1
!
ip vrf green
 description Customer2
!
interface vlan11
 ip vrf forwarding red
 ip address 10.1.1.1/24
[cont...]
```

```
!
interface vlan12
 ip vrf forwarding red
 ip address 10.2.2.1/24
!
interface vlan13
 ip vrf forwarding green
 ip address 10.1.1.1/24
!
interface vlan14
 ip vrf forwarding green
 ip address 10.2.2.1/16
!
router ospf 1 red
 network 10.1.1.0/24 area 0
 network 10.2.2.0/24 area 0
 redistribute connected
!
router ospf 2 green
 network 10.1.1.0/24 area 0
 network 10.2.0.0/16 area 0
 redistribute connected
!
...
```

VRFs accessing a shared network. An example of static inter-VRF routing

The partial configuration example below shows the key components required to support static inter-VRF routing.

Two companies (VRF red and VRF green) are able to access shared vlan100. Shared vlan100 exists in the Global default VRF. Static inter-VRF routing is used in this example to facilitate inter-VRF communication. There are no overlapping IP addresses. As there is no external router in vlan100 and there is no Internet access via vlan100, ACLs are not required.




```
...
!
ip vrf red
!
ip vrf green
!
interface vlan12
 ip vrf forwarding red
 ip address 1.10.1.1/24
!
interface vlan14
 ip vrf forwarding green
 ip address 1.20.1.1/24
!
interface vlan100
 ip address 100.100.100.100/24
!
ip route vrf red 0.0.0.0/0 vlan100
ip route vrf green 0.0.0.0/0 vlan100
ip route 1.10.1.0/24 vlan12
ip route 1.20.1.0/24 vlan14
!
...
```

Dynamic inter-VRF communication with RIP routing to external peers

The partial configuration example below shows the key components required to support dynamic inter-VRF communication between two VRF instances using BGP, with RIP routing to external peers.

RIP address-families are created, and each RIP address-family is associated with a VRF instance. To achieve inter-VRF communications, BGP is redistributed into each RIP family. Conversely, BGP address-families are created and each BGP address-family is associated with a VRF instance, and RIP is redistributed into each BGP address-family. Connected routes are also redistributed into BGP to be leaked between VRF instances.

```
...
!
ip vrf red
 rd 100:1
 route-target export 100:1
 route-target import 100:2
!
ip vrf green
 rd 100:2
 route-target export 100:2
 route-target import 100:1
!
router rip
 !
 address-family ipv4 vrf red
 network vlan20
 redistribute bgp
 exit-address-family
 !
 address-family ipv4 vrf green
 network vlan60
 redistribute bgp
 exit-address-family
!
router bgp 100
 address-family ipv4 vrf red
 redistribute connected
 redistribute rip
 exit-address-family
 !
 address-family ipv4 vrf green
 redistribute connected
 redistribute rip
 exit-address-family
!
...
```

Dynamic inter-VRF communication with BGP routing to external peers

The partial configuration example below shows the key components required to support dynamic inter-VRF communication using BGP, with BGP routing to external peers.

BGP address-families are created. Each BGP address-family is associated with a VRF instance. Routes within the VRF domain are advertised to external BGP peers. Selected BGP routes (including connected routes redistributed into BGP, and BGP routes learned from external BGP neighbors) are copied between VRF instances.

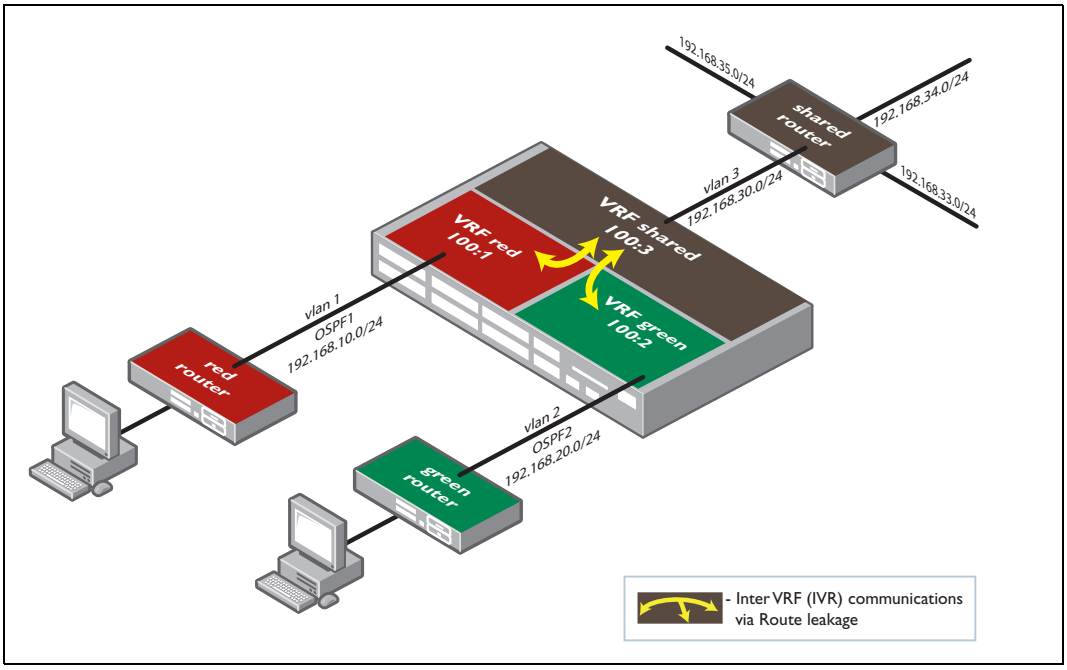
```
...
!
ip vrf red
 rd 100:1
 route-target export 100:1
 route-target import 100:2
!
ip vrf green
 rd 100:2
 route-target export 100:2
 route-target import 100:1
!
router bgp 100
 !
 address-family ipv4 vrf red
 redistribute connected
 neighbor 1.1.1.1 remote-as 100
 neighbor 1.1.1.1 activate
 exit-address-family
 !
 address-family ipv4 vrf green
 neighbor 2.2.2.2 remote-as 200
 neighbor 2.2.2.2 activate
 redistribute connected
 exit-address-family
 !
...
```

Dynamic inter-VRF communication with OSPF routing to external peers

The complete configuration example below shows the key components required to support dynamic inter-VRF communication using BGP, with OSPF routing to external peers.

VRFs red, green and shared are configured. VRFs red and green can access VRF shared, but not each other. OSPF routing is used in VRFs red and green, and these routes are leaked into VRF shared via BGP. The connected routes in VRFs red, green and shared are also redistributed into BGP to be leaked between VRF instances.

There are also three static routes configured in VRF shared to access shared router networks. ACLs and associated route maps and VRF import maps are used to selectively leak routes from VRF shared to VRFs red and green. For example, VRF red will selectively learn routes to VRF shared networks 192.168.30.0/24 and 192.168.33.0/24, and VRF green will selectively learn routes to VRF shared networks192.168.30.0/24 and 192.168.35.0/24.



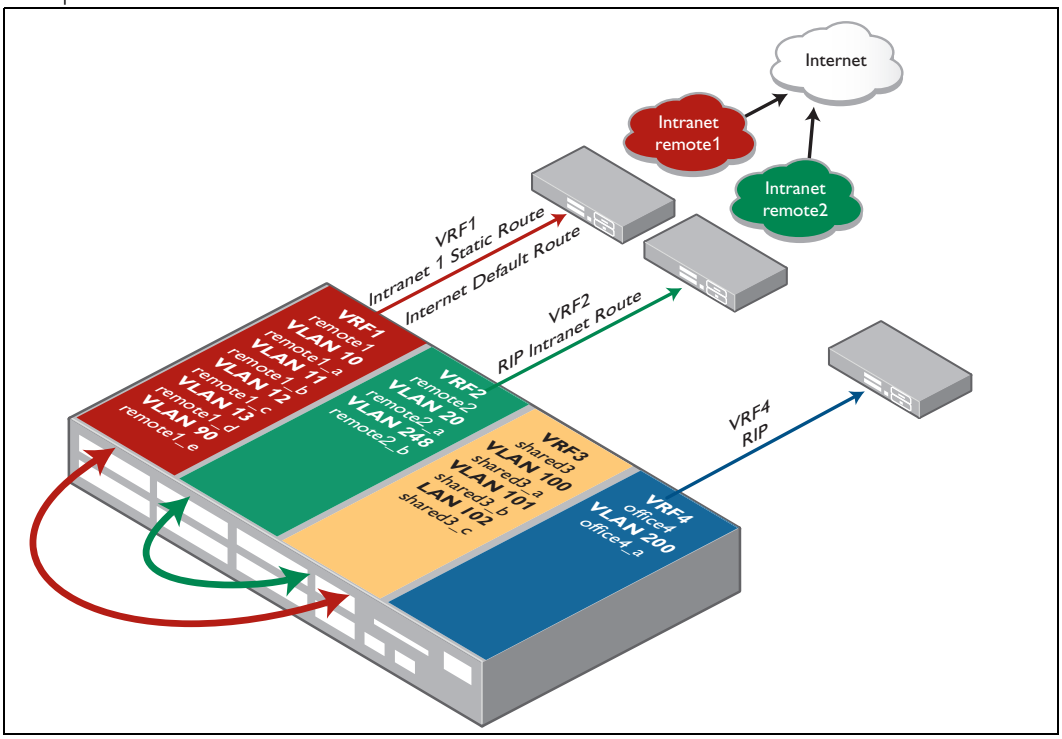
```
!
access-list standard greenBlock3334 deny 192.168.33.0/24
access-list standard greenBlock3334 deny 192.168.34.0/24
access-list standard greenBlock3334 permit any
access-list standard redBlock3435 deny 192.168.34.0/24
access-list standard redBlock3435 deny 192.168.35.0/24
access-list standard redBlock3435 permit any
!
ip vrf red
 rd 100:1
 route-target export 100:1
 route-target import 100:3
 import map red33
!
ip vrf green
 rd 100:2
 route-target export 100:2
 route-target import 100:3
 import map green35
!
ip vrf shared
 rd 100:3
 route-target import 100:1
 route-target import 100:2
 route-target export 100:3
!
vlan database
 vlan 2-3 state enable
!
interface port1.0.1
 switchport
 switchport mode access
!
interface port1.0.2
 switchport
 switchport mode access
 switchport access vlan 2
!
interface port1.0.3
 switchport
 switchport mode access
 switchport access vlan 3
!
interface port1.0.4-1.0.26
 switchport
 switchport mode access
!
[cont...]
```

```
interface vlan1
 ip vrf forwarding red
 ip address 192.168.10.1/24
!
interface vlan2
 ip vrf forwarding green
 ip address 192.168.20.1/24
!
interface vlan3
 ip vrf forwarding shared
 ip address 192.168.30.1/24
!
router ospf 1 red
 network 192.168.10.0/24 area 0
 redistribute bgp
!
router ospf 2 green
 network 192.168.20.0/24 area 0
 redistribute bgp
!
router bgp 100
 address-family ipv4 vrf red
 redistribute ospf
 redistribute connected
 exit-address-family
 !
 address-family ipv4 vrf green
 redistribute ospf
 redistribute connected
 exit-address-family
 !
 address-family ipv4 vrf shared
 redistribute static
 redistribute connected
 exit-address-family
!
ip route vrf shared 192.168.33.0/24 192.168.30.3
ip route vrf shared 192.168.34.0/24 192.168.30.3
ip route vrf shared 192.168.35.0/24 192.168.30.3
!
route-map red33 permit 1
 match ip address redBlock3435
!
route-map green35 permit 1
 match ip address greenBlock3334
!
line con 0
line vty 0 4
!
end
```

Inter-VRF configuration examples with Internet access

The following three complete examples are using a similar topology, however, each example involves a different communication plan and a variety of routing protocols. All of the following examples utilise one or more Internet connections.

Example A



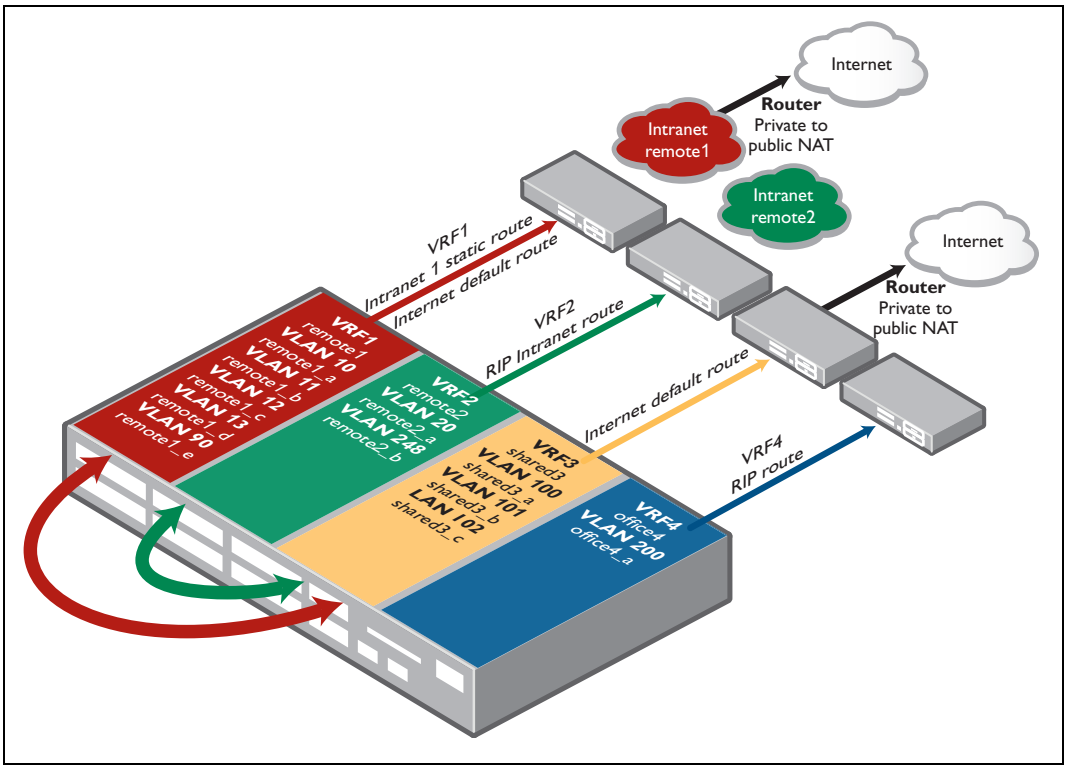
COMMUNICATION PLAN
VRF3 has communication with VRF1 VRF3 has communication with VRF2
No communication between: VRF1 and VRF2 VRF1 and VRF4 VRF2 and VRF4 VRF3 and VRF4
Intranet remote1 and Intranet remote2 have IP address plan overlapping (vlan 10 and vlan20 respectively). There is no inter-VRF communication from VRF3 to overlapping networks associated with vlan10 and vlan20.
Inter-VRF communication (VLAN to VLAN) are handled by static inter-VRF routes
VRF1 has access to the Internet via its Intranet remote 1 connection via vlan10 VRF2 has access to the Internet via its Intranet remote 2 connection via vlan20 VRF3 has no Internet access

Configuration

```
!
ip vrf remote1 1
!
ip vrf remote2 2
!
ip vrf shared3 3
!
ip vrf office4 4
!
vlan database
 vlan 10 name remote1_a
 vlan 11 name remote1_b
 vlan 12 name remote1_c
 vlan 13 name remote1_d
 vlan 20 name remote2_a
 vlan 90 name remote1_e
 vlan 100 name shared3_a
 vlan 101 name shared3_b
 vlan 102 name shared3_c
 vlan 200 name office4_a
 vlan 248 name remote2_b
 vlan 10-13,20,90,100-102,200,248 state enable
!
interface port1.0.1
 switchport
 switchport mode trunk
 switchport trunk allowed vlan add 10-13,90
!
interface port1.0.2
 switchport
 switchport mode trunk
 switchport trunk allowed vlan add 20,248
!
interface port1.0.3
 switchport
 switchport mode trunk
 switchport trunk allowed vlan add 100-102
!
interface port1.0.4
 switchport
 switchport mode trunk
 switchport trunk allowed vlan add 200
!
interface port1.0.5
 switchport
 switchport mode access
 switchport access vlan 100
!
interface port1.0.6-1.0.26
 switchport
 switchport mode access
!
interface vlan10
 ip vrf forwarding remote1
 ip address 10.0.0.1/8
!
interface vlan11
 ip vrf forwarding remote1
 ip address 11.0.0.1/8
!
interface vlan12
 ip vrf forwarding remote1
 ip address 12.0.0.1/8
```

```
!
interface vlan13
 ip vrf forwarding remote1
 ip address 13.0.0.1/8
!
interface vlan20
 ip vrf forwarding remote2
 ip address 10.0.0.1/8
!
interface vlan90
 ip vrf forwarding remote1
 ip address 14.0.0.1/8
!
interface vlan100
 ip vrf forwarding shared3
 ip address 30.0.0.1/8
!
interface vlan101
 ip vrf forwarding shared3
 ip address 31.0.0.1/8
!
interface vlan102
 ip vrf forwarding shared3
 ip address 32.0.0.1/8
!
interface vlan200
 ip vrf forwarding office4
 ip address 40.0.0.1/8
!
interface vlan248
 ip vrf forwarding remote2
 ip address 20.0.0.1/8
!
router rip
 !
 address-family ipv4 vrf remote2
 network vlan20
 redistribute connected
 exit-address-family
 !
 address-family ipv4 vrf office4
 network vlan200
 exit-address-family
!
ip route vrf remote1 0.0.0.0/0 10.0.0.2
ip route vrf remote1 30.0.0.0/8 vlan100
ip route vrf remote1 31.0.0.0/8 vlan101
ip route vrf remote1 32.0.0.0/8 vlan102
ip route vrf remote1 80.0.0.0/8 10.0.0.2
ip route vrf remote2 0.0.0.0/0 10.0.0.2
ip route vrf remote2 30.0.0.0/8 vlan100
ip route vrf remote2 31.0.0.0/8 vlan101
ip route vrf remote2 32.0.0.0/8 vlan102
ip route vrf shared3 11.0.0.0/8 vlan11
ip route vrf shared3 12.0.0.0/8 vlan12
ip route vrf shared3 13.0.0.0/8 vlan13
ip route vrf shared3 14.0.0.0/8 vlan90
ip route vrf shared3 20.0.0.0/8 vlan248
!
line con 0
line vty 0 4
!
end
```

Example B



COMMUNICATION PLAN
VRF3 has communication with VRF1 VRF3 has communication with VRF2
No communication between: VRF1 and VRF2 VRF1 and VRF4 VRF2 and VRF4 VRF3 and VRF4
Intranet remote1 and Intranet remote2 have IP address plan overlapping (vlan 10 and vlan20 respectively). There is no inter-VRF communication from VRF3 to overlapping networks associated with vlan10 and vlan20.
inter-VRF communication is limited to connected interface routes only. Inter- VRF communication (VLAN to VLAN) are handled by dynamic inter-VRF routing
VRF1 has access to the Internet via Intranet remote1 VLAN10 VRF2 has no Internet access VRF3 has access to the Internet via vlan100

Configuration

```
!
access-list standard deny_overlap deny 10.0.0.0/8
access-list standard deny_overlap permit any
!
ip vrf remote1 1
 rd 100:1
 route-target export 100:1
 route-target import 100:3
 export map block10
!
ip vrf remote2 2
 rd 100:2
 route-target export 100:2
 route-target import 100:3
 export map block10
!
ip vrf shared3 3
 rd 100:3
 route-target import 100:1
 route-target import 100:2
 route-target export 100:3
!
ip vrf office4
!
vlan database
 vlan 10 name remote1_a
 vlan 11 name remote1_b
 vlan 12 name remote1_c
 vlan 13 name remote1_d
 vlan 20 name remote2_a
 vlan 90 name remote1_e
 vlan 100 name shared3_a
 vlan 101 name shared3_b
 vlan 102 name shared3_c
 vlan 200 name office4_a
 vlan 248 name remote2_b
 vlan 10-13,20,90,100-102,200,248 state enable
!
interface port1.0.1
 switchport
 switchport mode trunk
 switchport trunk allowed vlan add 10-13,90
!
interface port1.0.2
 switchport
 switchport mode trunk
 switchport trunk allowed vlan add 20,248
!
interface port1.0.3
 switchport
 switchport mode trunk
 switchport trunk allowed vlan add 100-102
!
interface port1.0.4
 switchport
 switchport mode trunk
 switchport trunk allowed vlan add 200
!
interface port1.0.5
 switchport
 switchport mode access
 switchport access vlan 100
```

```
!
interface port1.0.6-1.0.26
 switchport
 switchport mode access
!
interface vlan10
 ip vrf forwarding remote1
 ip address 10.0.0.1/8
!
interface vlan11
 ip vrf forwarding remote1
 ip address 11.0.0.1/8
!
interface vlan12
 ip vrf forwarding remote1
 ip address 12.0.0.1/8
!
interface vlan13
 ip vrf forwarding remote1
 ip address 13.0.0.1/8
!
interface vlan20
 ip vrf forwarding remote2
 ip address 10.0.0.1/8
!
interface vlan90
 ip vrf forwarding remote1
 ip address 14.0.0.1/8
!
interface vlan100
 ip vrf forwarding shared3
 ip address 30.0.0.1/8
!
interface vlan101
 ip vrf forwarding shared3
 ip address 31.0.0.1/8
!
interface vlan102
 ip vrf forwarding shared3
 ip address 32.0.0.1/8
!
interface vlan200
 ip vrf forwarding office4
 ip address 40.0.0.1/8
!
interface vlan248
 ip vrf forwarding remote2
 ip address 20.0.0.1/8
!
router rip
 !
 address-family ipv4 vrf remote2
 network vlan20
 redistribute connected
 exit-address-family
 !
 address-family ipv4 vrf office4
 network vlan200
 exit-address-family
!
router bgp 100
 address-family ipv4 vrf remote1
 redistribute connected
 exit-address-family
```

```
 !
 address-family ipv4 vrf remote2
 redistribute connected
 exit-address-family
 !
 address-family ipv4 vrf shared3
 redistribute connected
 exit-address-family
!
ip route vrf remote1 0.0.0.0/0 10.0.0.2
ip route vrf shared3 0.0.0.0/0 30.0.0.2
ip route vrf remote1 80.0.0.0/8 10.0.0.2
!
route-map block10 permit 1
 match ip address deny_overlap
!
```

Additional note:

If VRF remote2 needs to have its own Internet access via vlan20, either:

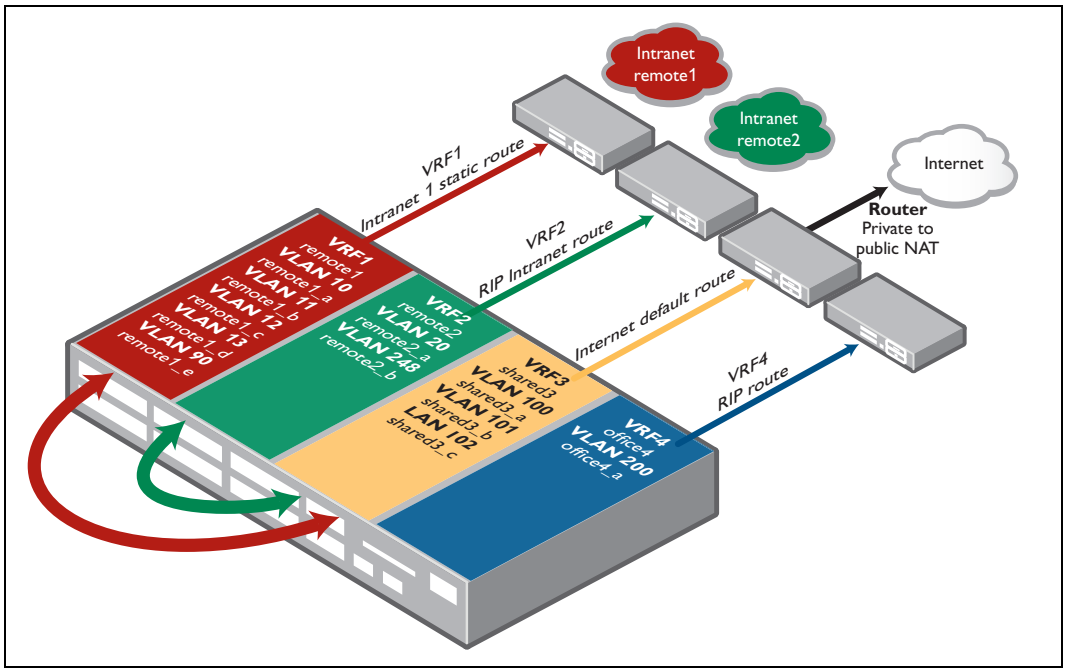
- add a static default route into this device:

ip route vrf remote2 0.0.0.0/0 10.0.0.2

Or

- Configure Intranet remote2 RIP peer with default-originate (redistribute default route to RIP peer) and hence ensure Intranet remote2 RIP peer advertises the default route via RIP to this VRF aware device.

Example C



COMMUNICATION PLAN
VRF3 has communication with VRF1 VRF3 has communication with VRF2
No communication between: VRF1 and VRF2 VRF1 and VRF4 VRF2 and VRF4 VRF3 and VRF4
Intranet remote1 and Intranet remote2 have IP address plan overlapping (vlan 10 and vlan20 respectively). There is no inter-VRF communication from VRF3 to overlapping networks associated with vlan10 and vlan20.
Inter-VRF communication is limited to connected interface routes only. Inter-VRF communications (VLAN to VLAN) are handled by dynamic inter-VRF routing.
VRF1 and VRF2 can both access the Internet via shared VRF3 vlan100, however additional HW ACLs are now required to prevent data from VRF1 being routed via Internet access router back to VRF2 and vice-versa.

Configuration

```
!
access-list standard deny_overlap deny 10.0.0.0/8
access-list standard deny_overlap permit any
!
ip vrf remote1 1
 rd 100:1
 route-target export 100:1
 route-target import 100:3
 export map block10
!
ip vrf remote2 2
 rd 100:2
 route-target export 100:2
 route-target import 100:3
 export map block10
!
ip vrf shared3 3
 rd 100:3
 route-target import 100:1
 route-target import 100:2
 route-target export 100:3
!
ip vrf office4 4
!
access-list hardware deny_to_vrf1
 deny ip any 11.0.0.0/8
 deny ip any 12.0.0.0/8
 deny ip any 13.0.0.0/8
 deny ip any 14.0.0.0/8
access-list hardware deny_to_vrf2
 deny ip any 20.0.0.0/8
!
vlan database
 vlan 10 name remote1_a
 vlan 11 name remote1_b
 vlan 12 name remote1_c
 vlan 13 name remote1_d
 vlan 20 name remote2_a
 vlan 90 name remote1_e
 vlan 100 name shared3_a
 vlan 101 name shared3_b
 vlan 102 name shared3_c
 vlan 200 name office4_a
 vlan 248 name remote2_b
 vlan 10-13,20,90,100-102,200,248 state enable
!
interface port1.0.1
 switchport
 switchport mode trunk
 switchport trunk allowed vlan add 10-13,90
 access-group deny_to_vrf2
!
interface port1.0.2
 switchport
 switchport mode trunk
 switchport trunk allowed vlan add 20,248
 access-group deny_to_vrf1
!
interface port1.0.3
 switchport
 switchport mode trunk
 switchport trunk allowed vlan add 100-102
```

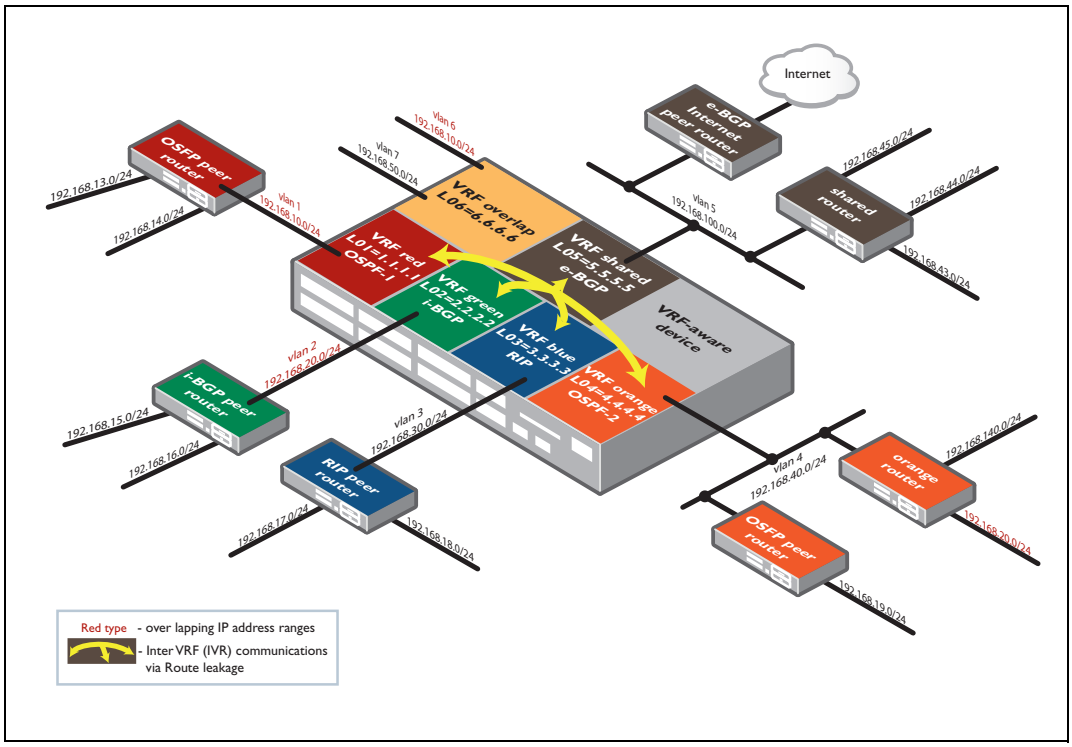
```
!
interface port1.0.4
 switchport
 switchport mode trunk
 switchport trunk allowed vlan add 200
!
interface port1.0.5
 switchport
 switchport mode access
 switchport access vlan 100
!
interface port1.0.6-1.0.26
 switchport
 switchport mode access
!
interface vlan10
 ip vrf forwarding remote1
 ip address 10.0.0.1/8
!
interface vlan11
 ip vrf forwarding remote1
 ip address 11.0.0.1/8
!
interface vlan12
 ip vrf forwarding remote1
 ip address 12.0.0.1/8
!
interface vlan13
 ip vrf forwarding remote1
 ip address 13.0.0.1/8
!
interface vlan20
 ip vrf forwarding remote2
 ip address 10.0.0.1/8
!
interface vlan90
 ip vrf forwarding remote1
 ip address 14.0.0.1/8
!
interface vlan100
 ip vrf forwarding shared3
 ip address 30.0.0.1/8
!
interface vlan101
 ip vrf forwarding shared3
 ip address 31.0.0.1/8
!
interface vlan102
 ip vrf forwarding shared3
 ip address 32.0.0.1/8
!
interface vlan200
 ip vrf forwarding office4
 ip address 40.0.0.1/8
!
interface vlan248
 ip vrf forwarding remote2
 ip address 20.0.0.1/8
!
router rip
 !
 address-family ipv4 vrf remote2
 network vlan20
 redistribute connected
```

```
 exit-address-family
 !
 address-family ipv4 vrf office4
 network vlan200
 exit-address-family
!
router bgp 100
 address-family ipv4 vrf remote1
 redistribute connected
 exit-address-family
 !
 address-family ipv4 vrf remote2
 redistribute connected
 exit-address-family
 !
 address-family ipv4 vrf shared3
 redistribute connected
 exit-address-family
!
ip route vrf remote1 0.0.0.0/0 30.0.0.2 vlan100
ip route vrf remote2 0.0.0.0/0 30.0.0.2 vlan100
ip route vrf shared3 0.0.0.0/0 30.0.0.2
ip route vrf remote1 80.0.0.0/8 10.0.0.2
!
route-map block10 permit 1
 match ip address deny_overlap
```

Configuring a complex inter-VRF solution

A network comprising of multiple devices that demonstrates inter-VRF routing. A variety of routing protocols are used in this example.

Network description



The VRF-aware device has six separate VRFs configured, they are named: red, green, blue, orange, shared and overlap. The VRF-aware device has static routes to two router networks (orange router and shared router). It also peers to two OSPF routers (OSPF red peer and OSPF orange peer), one i-BGP peer (i-BGP green peer) and one RIPv2 peer (RIP blue peer), and one e-BGP peer (e-BGP shared Internet peer) that allows Internet access. None of the peer devices are VRF aware. Dynamic inter-VRF communication allows selected VRFs to access a common shared Internet connection.

- Each VLAN(s) is associated with a VRF instance.
- Each VRF instance also has its own unique IP local interface and associated local IP address.
- Each VRF contains its own separate IP routing domain and separate (OSPF) routing protocol instance or (BGP/RIP) address-family.

The VRF instances red, green, blue, and orange, are all able to access the Internet via VRF shared. They also have filtered access to 'shared router' subnets. All inter-VRF communication between VRFs red, green, blue, and orange is blocked.

BGP, route-maps, and Access Control Lists (ACLs) are used to 'leak' selected routes between VRFs to allow filtered inter-VRF (IVR) communication.

VRF communication plan

- VRF shared can access all VRFs red, green, blue and orange (excluding VRF overlap).
- VRFs red, green, blue, and orange are only able to access VRF shared. They cannot access each other in this example.
- VRF overlap remains completely isolated from all other VRFs, and it has a connected route to subnet 192.168.10.0/24, which is also configured in VRF red. No routes are exported from or imported to VRF overlap, ensuring there is no IP address range overlap conflict when performing inter-VRF communication.
- VRF red can access the Internet, and VRF shared subnets, 192.168.100.0/24, 192.168.43.0/24, but VRF red cannot access VRF shared subnets 192.168.44.0/24, 192.168.45.0/24.
- VRF red has a connected route to subnet 192.168.10.0/24, which is also configured in VRF overlap. This connected route in VRF red is leaked to other VRFs.
- VRF green can access the Internet, and VRF shared subnets, 192.168.100.0/24, 192.168.44.0/24, but VRF green cannot access VRF shared subnets 192.168.43.0/24, 192.168.45.0/24.
- VRF green has a connected route to subnet 192.168.20.0/24, which overlaps a static route configured in VRF orange. This connected route in VRF green is leaked to other VRFs.
- VRF blue can access the Internet, and VRF shared subnets, 192.168.100.0/24, 192.168.45.0/24, but VRF blue cannot access VRF shared subnets 192.168.43.0/24, 192.168.44.0/24.
- VRF orange can access the Internet, and can also access all VRF shared subnets, 192.168.100.0/24, 192.168.43.0/24,192.168.44.0/24, 192.168.45.0/24.
- VRF orange has static route to subnet 192.168.20.0/24, which overlaps a connected route configured in VRF green. Therefore this subnet is not leaked from VRF orange to other VRF instances, ensuring there is no IP address range overlap conflict when performing inter-VRF communication.

Configuration breakdown

When configuring a complex inter-VFR aware device, such as in our example, the configuration order is important. We have provided a breakdown before each step to explain the key points you will need to consider.

Configure the standard ACLs

These standard ACL's are associated with routes maps. The route maps are referenced by VRF import and export maps. VRF export maps filter routes exported to BGP. VRF import maps filter routes imported into the VRF domain from BGP. BGP is used to leak routes between VRFs.

These ACLs should be configured before any inter-VRF communication is configured, to prevent unnecessary routes from being leaked from one VRF to another.

CONFIGURE STANDARD ACLS

```
awplus#conf t
Enter configuration commands, one per line. End with CNTL/Z.
awplus(config)#access-list standard blueBlock4344 deny 192.168.43.0/24
awplus(config)#access-list standard blueBlock4344 deny 192.168.44.0/24
awplus(config)#access-list standard blueBlock4344 permit any
awplus(config)#access-list standard greenBlock4345 deny 192.168.43.0/24
awplus(config)#access-list standard greenBlock4345 deny 192.168.45.0/24
awplus(config)#access-list standard greenBlock4345 permit any
awplus(config)#access-list standard orangeBlock20Export140 deny 192.168.20.0/24
awplus(config)#access-list standard orangeBlock20Export140 permit any
awplus(config)#access-list standard orangeNoBlock permit any
awplus(config)#access-list standard redBlock4445 deny 192.168.44.0/24
awplus(config)#access-list standard redBlock4445 deny 192.168.45.0/24
awplus(config)#access-list standard redBlock4445 permit any
```

Configure the VRFs

Next we configure the six numbered VRFs named red, green, blue, orange, shared and overlap, via the command **ip vrf-name number**

The optional number parameter creates and assigns a local interface (LO) to the VRF instance. This number parameter allows the user to manually control which local interface is associated with each VRF. If not specified, a local interface is automatically created and assigned to the VRF instance in the order of VRF creation. Once an LO is created, it remains assigned to the VRF (including over a reboot), unless manually changed by the user.

Only a single local interface per VRF is supported, and each local interface can be configured with its own local ip address.

A local interface (also referred to as an internal loopback interface) is an internal interface that is always available for higher layer protocols to use and advertise to the network. Although a local interface is assigned an IP address, it does not have the usual requirement of connecting to a lower layer physical entity.

Local interfaces can be utilised by a number of protocols for various purposes. They can be used as a reliable address via which to access a device - an address that is always accessible, irrespective of the link status of any individual external interface.

Within each VRF, configure optional route distinguisher (RD), route-targets and VRF import and export maps. The RD, route-targets and VRF import and export maps are used when leaking routes via BGP. They are not required when inter-VRF communication is achieved via static inter-VRF routes. BGP is used to facilitate inter-VRF communication in this example.

The RD is a BGP ASN (xxx:). The VRF RD is also used by MPLS to facilitate VRF VPNs, which are currently not supported, and thus serves little purpose in the context of VRF-lite. However the **RD** command is required if using BGP to facilitate inter-VRF communications. Each RD references a unique VRF instance (:xxx). A complete VRF ASN uses the syntax xxx:xxx. For example 100:1 denotes BGP ASN 100, VRF instance1.

The command **route-target export xxx:xxx** enables routes in the VRF domain with a matching VRF ASN tag to be exported via BGP to be subsequently leaked to other VRFs.

The command **route-target import xxx:xxx** enables routes from other VRF domains with a matching VRF ASN tag to be imported via BGP into the VRF domain.

The command **export map name** references a route map, which in turn references the ACLs previously configured. This command ensures (via the associated ACLs) that only selected routes are exported from the VRF domain to BGP.

In this example VRF orange has a static route to network 192.168.20.0/24. This same IP subnet is assigned to vlan 2, which is a part of VRF green. Therefore there is an export map (orange 140) and associated ACL orangeBlock20Export140 deny 192.168.20.0/24 to ensure the network 192.168.20.0 is not exported into BGP, whilst still allowing the export of other networks that do not match the ACL.

The command **import map name** references a route map, which in turn references the ACLs previously configured. This commands ensures (via the associated ACLs) that only selected routes are imported into the VRF domain from BGP.

There is no route leakage to or from VRF overlap. VRF overlap (and its associated VLANs) remain completely isolated from all other VRF domains. VRF overlap contains network 192.168.10.0/24 associated with vlan6. This same subnet is also contained in VRF red vlan1. This is OK, as VRF overlap has no associated **route-target import** and **route-target export** commands.

CONFIGURE VRFS

```
awplus(config)#ip vrf red 1
awplus(config-vrf)#rd 100:1
awplus(config-vrf)#route-target export 100:1
awplus(config-vrf)#route-target import 100:5
awplus(config-vrf)#import map red43
awplus(config-vrf)#exit
awplus(config)#ip vrf green 2
awplus(config-vrf)#rd 100:2
awplus(config-vrf)#route-target export 100:2
awplus(config-vrf)#route-target import 100:5
awplus(config-vrf)#import map green44
awplus(config-vrf)#exit
awplus(config)#ip vrf blue 3
awplus(config-vrf)#rd 100:3
awplus(config-vrf)#route-target export 100:3
awplus(config-vrf)#route-target import 100:5
awplus(config-vrf)#import map blue45
awplus(config-vrf)#exit
awplus(config)#ip vrf orange 4
awplus(config-vrf)#rd 100:4
awplus(config-vrf)#route-target export 100:4
awplus(config-vrf)#route-target import 100:5
awplus(config-vrf)#import map orange434445
awplus(config-vrf)#export map orange140
awplus(config-vrf)#exit
awplus(config)#ip vrf shared 5
awplus(config-vrf)#rd 100:5
awplus(config-vrf)#route-target import 100:1
awplus(config-vrf)#route-target import 100:2
awplus(config-vrf)#route-target import 100:3
awplus(config-vrf)#route-target import 100:4
awplus(config-vrf)#route-target export 100:5
awplus(config-vrf)#exit
awplus(config)#ip vrf overlap 6
awplus(config-vrf)#exit
```

Configure the hardware ACLs

The command **access-list hardware <name>** creates the hardware access list. The access list is associated with individual switch ports as an access-group. Each access group contains one or more filters, which filter source traffic ingressing the switch port based on the filter entry order.

Each individual filter in the example below match on IP traffic destined to a specific network from any source IP.

Any IP traffic not matching an ACL is implicitly permitted. This allows traffic not filtered to be able to access the Internet.

Note - these traffic filters are being used for quite a different purpose than the ACLs that are used in the route-maps for controlling which routes are leaked between VRFs.

Instead, these filters are checking individual packets that are coming into the switch, and blocking those packets that are trying to reach IP addresses that should not be reachable from their VRF domain.

Via the filters, the switch knows which IP subnets should not be reachable from a given domain, and so can drop any packets that are trying to reach IP addresses in those subnets.

The dropping (filtering) of those ingress packets is important in the case where a VRF has a default route to a shared VRF and there is an external router that exists in the shared VRF. If there is no external router in the shared VRF or VRF has no default route via the shared VRF, then these IP hardware filters are not required.

Without these filters, traffic which has source IP within one VRF to destination IP within another VRF will be routed via the shared VRF to the external router (the external Internet BGP router in this example). The external router will route the traffic back to the shared VRF, which will in turn route the traffic to the destination IP within the destination VRF. And the packet will be replied to. In effect, the external router inadvertently breaks the inter-VRF security.

Without the external router, although the shared VRF has routes to the other VRF domains, the VRF device will maintain the inter-VRF security. Traffic from one VRF will be unable to access another VRF via the shared VRF. In that case the hardware traffic filters are not so important, but they can still be used to prevent any accidental forwarding (by some external device) of traffic from one VRF to another VRF that the traffic should not be able to access.

CONFIGURE HARDWARE ACLS

```
awplus(config)#access-list hardware access43
awplus(config-ip-hw-acl)#permit ip any 192.168.43.0/24
awplus(config-ip-hw-acl)#exit
awplus(config)#access-list hardware access44
awplus(config-ip-hw-acl)#permit ip any 192.168.44.0/24
awplus(config-ip-hw-acl)#exit
awplus(config)#access-list hardware access45
awplus(config-ip-hw-acl)#permit ip any 192.168.45.0/24
awplus(config-ip-hw-acl)#exit
awplus(config)#access-list hardware allow100_deny_private
awplus(config-ip-hw-acl)#permit ip any 192.168.100.0/24
awplus(config-ip-hw-acl)#deny ip any 192.168.0.0/16
awplus(config-ip-hw-acl)#exit
awplus(config)# access-list hardware allow_to_self_10
awplus(config-ip-hw-acl)#permit ip any 192.168.10.0/24
awplus(config-ip-hw-acl)#exit
awplus(config)# access-list hardware allow_to_self_20
awplus(config-ip-hw-acl)#permit ip any 192.168.20.0/24
awplus(config-ip-hw-acl)#exit
awplus(config)# access-list hardware allow_to_self_30
awplus(config-ip-hw-acl)#permit ip any 192.168.30.0/24
awplus(config-ip-hw-acl)#exit
awplus(config)# access-list hardware allow_to_self_40
awplus(config-ip-hw-acl)#permit ip any 192.168.40.0/24
awplus(config-ip-hw-acl)#exit
```

Configure the VLANs

VLANs are created in the VLAN database, and ports are assigned to relevant VLANs.

The access lists are assigned in order to the individual switch ports as access groups. The order in which the access groups are attached to a port is important - packets are matched against the ACLs in the order they are attached to the interface.

In this example, three access groups are attached to port 1.0.1.

The first access group allow_to_self_10 permits traffic that has destination IP (192.168.10.0/24) within the same IP subnet that the switch port is a member of.

The second access group access43 permits traffic that has destination IP (192.168.43.0/24) within the external shared router subnet. This allows VRF red to access the subnet 192.168.43.0/24 via the shared VRF.

The third access group allow100_deny_private permits VRF red to access shared VRF network 192.168.100.0/24. Subsequently traffic to all networks within the 192.168.0.0/16 address ranges is denied.

The order of filtering is:

1. Allow access to the subnet in which the port resides.
2. Allow access to specific remote networks via shared.
3. Allow access to the 192.168.100.0/24 address range, then deny access to all other networks within the 192.168.0.0/16 address ranges.
4. And implicitly, all other traffic not matching the ACLs is allowed to access the Internet.

CONFIGURE VLAN DATABASE

```
awplus(config)#vlan database
awplus(config-vlan)#vlan 2-7 state enable
awplus(config-vlan)#exit
awplus(config)#interface port1.0.1
awplus(config-if)#access-group allow_to_self_10
awplus(config-if)#access-group access43
awplus(config-if)#access-group allow100_deny_private
awplus(config)#interface port1.0.2
awplus(config-if)#switchport access vlan 2
awplus(config-if)#access-group allow_to_self_20
awplus(config-if)#access-group access44
awplus(config-if)#access-group allow100_deny_private
awplus(config-if)#exit
awplus(config)#interface port1.0.3
awplus(config-if)#switchport access vlan 3
awplus(config-if)#access-group allow_to_self_30
awplus(config-if)#access-group access45
awplus(config-if)#access-group allow100_deny_private
awplus(config-if)#exit
awplus(config)#interface port1.0.4-1.0.5
awplus(config-if)#switchport access vlan 4
awplus(config-if)#access-group allow_to_self_40
awplus(config-if)#access-group access43
awplus(config-if)#access-group access44
awplus(config-if)#access-group access45
awplus(config-if)#access-group allow100_deny_private
awplus(config-if)#exit
awplus(config)#interface port1.0.6-1.0.7
awplus(config-if)#switchport access vlan 5
awplus(config-if)#exit
[cont...]
```

```
awplus(config)#interface port1.0.8
awplus(config-if)#switchport access vlan 6
awplus(config-if)#exit
awplus(config)#interface port1.0.9
awplus(config-if)#switchport access vlan 7
awplus(config-if)#exit
```

Configure the IP addresses

An IP address is allocated to each Local interface.

Also, VLANs are associated with each VRF instance. Each VRF instance can contain multiple VLANs. A VLAN cannot be allocated to multiple VRFs. Each VLAN is allocated an IP subnet. In the example below vlan 1 and vlan 6 are configured with the same IP network. The overlapping subnets is a key feature that VRF provides. This is valid as each of the VLANs reside in a different VRF domain.

CONFIGURE IP ADDRESSES

```
awplus(config-if)#interface lo1
awplus(config-if)#ip address 1.1.1.1/32
awplus(config-if)#exit
awplus(config)#interface lo2
awplus(config-if)#ip address 2.2.2.2/32
awplus(config-if)#exit
awplus(config-if)#exit
awplus(config)#interface lo3
awplus(config-if)#ip address 3.3.3.3/32
awplus(config-if)#exit
awplus(config)#interface lo4
awplus(config-if)#ip address 4.4.4.4/32
awplus(config-if)#exit
awplus(config)#interface lo5
awplus(config-if)#ip address 5.5.5.5/32
awplus(config-if)#exit
awplus(config)#interface lo6
awplus(config-if)#ip address 6.6.6.6/32
awplus(config-if)#exit
[cont...]
```

```
awplus(config)#interface vlan1
awplus(config-if)#ip vrf forwarding red
awplus(config-if)#ip address 192.168.10.1/24
awplus(config)#interface vlan2
awplus(config-if)#ip vrf forwarding green
awplus(config-if)#ip address 192.168.20.1/24
awplus(config-if)#exit
awplus(config)#interface vlan3
awplus(config-if)#ip vrf forwarding blue
awplus(config-if)#ip address 192.168.30.1/24
awplus(config-if)#exit
awplus(config)#interface vlan4
awplus(config-if)#ip vrf forwarding orange
awplus(config-if)#ip address 192.168.40.1/24
awplus(config-if)#exit
[awplus(config)#interface vlan5
awplus(config-if)#ip vrf forwarding shared
awplus(config-if)#ip address 192.168.100.1/24
awplus(config-if)#exit
awplus(config)#interface vlan6
awplus(config-if)#ip vrf forwarding overlap
awplus(config-if)#ip address 192.168.10.1/24
awplus(config-if)#exit
awplus(config)#interface vlan7
awplus(config-if)#ip vrf forwarding overlap
awplus(config-if)#ip address 192.168.50.1/24
awplus(config-if)#exit
```

Configure routing

Dynamic routing protocols are configured as required and associated with each VRF.

OSPF instance 1 is associated with VRF red. OSPF instance 2 is associated with VRF orange. RIP and BGP use address-families as the equivalent of OSPF instances. A RIP ipv4 address-family is created and associated with VRF blue. Appropriate IP networks are allocated to each routing protocol instance or address-family. BGP inter-VRF routes are imported and redistributed via each routing protocol instance or address-family. This allows each external peer router connected in each VRF domain to be taught filtered routes to subnets in VRF shared.

The command **default-information originate** ensures that OSPF or RIP within each VRF instance redistributes, and advertises to external peers in each VRF instance, a static default route to access the Internet via VRF shared.

CONFIGURE DYNAMIC ROUTING

```
awplus(config)#router ospf 1 red
awplus(config-router)#network 192.168.10.0/24 area 0
awplus(config-router)#redistribute bgp
awplus(config-router)#default-information originate
awplus(config-router)#exit
awplus(config)#router ospf 2 orange
awplus(config-router)#network 192.168.40.0/24 area 0
awplus(config-router)#redistribute static
awplus(config-router)#redistribute bgp
awplus(config-router)#default-information originate
awplus(config-router)#exit
awplus(config)#router rip
awplus(config-router)#address-family ipv4 vrf blue
awplus(config-router-af)#network 192.168.30.0/24
awplus(config-router-af)#redistribute bgp
awplus(config-router-af)#default-information originate
awplus(config-router-af)#exit-address-family
awplus(config-router)#exit
```

BGP with ASN 100 is configured. BGP is used to provide inter-VRF communication.

BGP address-families are created. Each BGP address-family is associated with a VRF instance, excluding VRF overlap. There is no route leakage to or from VRF overlap, so VRF overlap does not require an associated BGP address-family to be configured.

Via the address-families, routes (prefixes) from each routing protocol associated with each VRF instance are redistributed into BGP100. Via the VRF export maps, and ACLs they are subsequently leaked to and from VRF shared.

Connected (interface) routes and OSPF instance 1 routes associated with VRF red are imported and redistributed into BGP100.

Connected routes associated with VRF green are redistributed into BGP, and also advertised to the external BGP neighbor router. VRF green has an i-BGP peering relationship to its neighbor as the neighbor ASN is the same (ASN 100). BGP routes learned from the external i-BGP neighbor are added to BGP 100. As the connection is i-BGP (not e-BGP), the BGP command **next-hop-self** is required to ensure the next-hop IP address is modified for each prefix advertised to the external i-BGP peer. The next hop address becomes the VRF green vlan2 ip address '192.168.20.1'. Without this command inter-VRF routes advertised to the external i-BGP peer would retain the original next-hop IP address associated with VRF shared.

For example, the i-BGP standard dictates that without the command **next-hop-self**, the VRF shared route 192.168.44.0/24 leaked into VRF green would be advertised to the external VRF green i-BGP peer retaining the original VRF shared next-hop IP 192.168.100.2, instead of being modified to become the VRF green vlan2 IP 192.168.20.1.

The e-BGP standard dictates that the next-hop IP is automatically modified when advertising a prefix to an e-BGP neighbor, so the command **next-hop-self** is not required for external e-BGP peering relationships.

The **default-originate** command is required to ensure BGP redistributes the VRF green static default route to VRF green external i-BGP neighbor.

Connected routes and RIPv2 routes associated with VRF blue are imported and redistributed into BGP to be leaked to VRF shared.

Connected routes, OSPF instance 2 routes, and the static route associated with VRF orange are redistributed into BGP. VRF orange also has two static routes to orange router subnets 192.168.140.0/24 and 192.168.20.0/24. Only static route 192.168.140.0/24 is redistributed into BGP. Previously, VRF orange static route 192.168.20.0/24 was filtered via VRF export ACL as the network address range is also used elsewhere - with VRF green vlan2.

Connected routes and static routes associated with VRF shared are redistributed into BGP. VRF shared has static routes to external shared router networks 192.168.43.0/24, 192.168.44.0/24 and 192.168.45.0/24 as well as a static default route to the Internet. VRF shared has an e-BGP peering relationship to its internet-facing neighbor as the neighbor ASN is different (peer ASN = 300 instead of 100). The external Internet router learns routes to all networks associated with VRFs red, green, blue and orange via the e-BGP peering relationship.

Note: A unique AS number (ASN) is allocated to each AS for use in BGP routing. The numbers are assigned by IANA and the Regional Internet Registries (RIR), the same authorities that allocate IP addresses. There are public numbers, which may be used on the Internet and range from 1 to 64511, and private numbers from 64512 to 65535, which can be used within an organization.

CONFIGURE DYNAMIC ROUTING

```
awplus(config)#router bgp 100
awplus(config-router)#address-family ipv4 vrf red
awplus(config-router-af)#redistribute connected
awplus(config-router-af)#redistribute ospf
awplus(config-router-af)#exit-address-family
awplus(config-router)#address-family ipv4 vrf green
awplus(config-router-af)#redistribute connected
awplus(config-router-af)#neighbor 192.168.20.2 remote-as 100
awplus(config-router-af)#neighbor 192.168.20.2 next-hop-self
awplus(config-router-af)#neighbor 192.168.20.2 activate
awplus(config-router-af)#neighbor 192.168.20.2 default-originate
awplus(config-router-af)#exit-address-family
awplus(config-router)#address-family ipv4 vrf blue
awplus(config-router-af)#redistribute connected
awplus(config-router-af)#redistribute rip
awplus(config-router-af)#exit-address-family
awplus(config-router)#address-family ipv4 vrf orange
awplus(config-router-af)#redistribute connected
awplus(config-router-af)#redistribute static
awplus(config-router-af)#redistribute ospf
awplus(config-router-af)#exit-address-family
awplus(config-router)#address-family ipv4 vrf shared
awplus(config-router-af)#redistribute connected
awplus(config-router-af)#redistribute static
awplus(config-router-af)#neighbor 192.168.100.254 remote-as 200
awplus(config-router-af)#neighbor 192.168.100.254 activate
awplus(config-router-af)#exit-address-family
awplus(config-router)#exit
```

Static routes are configured. Each VRF instance is also configured with its own static default route (via VRF shared) to allow each of them to access the internet. Default routes are not able to be leaked dynamically via BGP between VRF instances as the BGP **default-originate** command only applies when peering to an external BGP neighbor.

The command **ip route <source-vrf-name> < dest-network> < next-hop-ip> <egress-vlan>** is used. For example the command **ip route vrf red 0.0.0.0/0 192.168.100.254 vlan5** denotes a static default route to the Internet which has a next-hop IP of 192.168.100.254 (192.168.100.254 is the IP address of the Internet router), which originates from VRF red, which egresses vlan5 in VRF shared.

The routes configured on VRF shared do not need to specify the egress VLAN, as they are not inter-VRF routes. So, the command **ip route vrf shared 192.168.45.0/24 192.168.100.2**

denotes a static route to destination network 192.168.45.0/24 which has a next hop of 192.168.100.2, which originates from VRF shared, which egresses VLAN5 in VRF shared. In this example each VRF instance red, green, blue, orange and shared has their own static default route to the Internet via VRF shared.

CONFIGURE STATIC ROUTING

```
awplus(config)#ip route vrf red 0.0.0.0/0 192.168.100.254 vlan5
awplus(config)#ip route vrf green 0.0.0.0/0 192.168.100.254 vlan5
awplus(config)#ip route vrf blue 0.0.0.0/0 192.168.100.254 vlan5
awplus(config)#ip route vrf orange 0.0.0.0/0 192.168.100.254 vlan5
awplus(config)#ip route vrf orange 192.168.20.0/24 192.168.40.2
awplus(config)#ip route vrf orange 192.168.140.0/24 192.168.40.2
awplus(config)#ip route vrf shared 0.0.0.0/0 192.168.100.254
awplus(config)#ip route vrf shared 192.168.43.0/24 192.168.100.2
awplus(config)#ip route vrf shared 192.168.44.0/24 192.168.100.2
awplus(config)#ip route vrf shared 192.168.45.0/24 192.168.100.2
```

Configure route maps

The final part of this configuration example is the route-map configuration. The command **route-map routemap-name permit 1** is used to create a route-map. Each route-map in turn references a particular standard ACL.

VRF export maps filter routes exported to BGP. VRF import maps filter routes imported into the VRF domain from BGP. BGP is used to leak routes between VRFs.

CONFIGURE ROUTE MAPS

```
awplus(config)#route-map red43 permit 1
awplus(config-route-map)#match ip address redBlock4445
awplus(config-route-map)#exit
awplus(config)#route-map green44 permit 1
awplus(config-route-map)#match ip address greenBlock4345
awplus(config-route-map)#exit
awplus(config)#route-map blue45 permit 1
awplus(config-route-map)#match ip address blueBlock4344
awplus(config-route-map)#exit
awplus(config)#route-map orange434445 permit 1
awplus(config-route-map)#match ip address orangeNoBlock
awplus(config-route-map)#exit
awplus(config)#route-map orange140 permit 1
awplus(config-route-map)#match ip address orangeBlock20Export140
awplus(config-route-map)#exit
awplus(config)#exits
```

Complete show run output from VRF device is below

```
awplus>ena
awplus#sh run
!
service password-encryption
!
no banner motd
!
username manager privilege 15 password 8 $1$bJoVec4D$JwOJGPr7YqoExA0GVasdE0
!
access-list standard blueBlock4344 deny 192.168.43.0/24
access-list standard blueBlock4344 deny 192.168.44.0/24
access-list standard blueBlock4344 permit any
access-list standard greenBlock4345 deny 192.168.43.0/24
access-list standard greenBlock4345 deny 192.168.45.0/24
access-list standard greenBlock4345 permit any
access-list standard orangeBlock20Export140 deny 192.168.20.0/24
access-list standard orangeBlock20Export140 permit any
access-list standard orangeNoBlock permit any
access-list standard redBlock4445 deny 192.168.44.0/24
access-list standard redBlock4445 deny 192.168.45.0/24
access-list standard redBlock4445 permit any
!
no service ssh
!
service telnet
!
service http
!
no clock timezone
!
snmp-server
!
exception coredump size unlimited
!
ip domain-lookup
!
no service dhcp-server
!
ip vrf red 1
 rd 100:1
 route-target export 100:1
 route-target import 100:5
 import map red43
!
ip vrf green 2
 rd 100:2
 route-target export 100:2
 route-target import 100:5
 import map green44
!
ip vrf blue 3
 rd 100:3
 route-target export 100:3
 route-target import 100:5
 import map blue45
!
ip vrf orange 4
 rd 100:4
 route-target export 100:4
 route-target import 100:5
 import map orange434445
 export map orange140
```

```
!
ip vrf shared 5
 rd 100:5
 route-target import 100:1
 route-target import 100:2
 route-target import 100:3
 route-target import 100:4
 route-target export 100:5
!
ip vrf overlap 6
!
no ip multicast-routing
!
spanning-tree mode rstp
!
access-list hardware access43
 permit ip any 192.168.43.0/24
access-list hardware access44
 permit ip any 192.168.44.0/24
access-list hardware access45
 permit ip any 192.168.45.0/24
access-list hardware allow100_deny_private
 permit ip any 192.168.100.0/24
 deny ip any 192.168.0.0/16
access-list hardware allow_to_self_10
 permit ip any 192.168.10.0/24
access-list hardware allow_to_self_20
 permit ip any 192.168.20.0/24
access-list hardware allow_to_self_30
 permit ip any 192.168.30.0/24
access-list hardware allow_to_self_40
 permit ip any 192.168.40.0/24
!
switch 1 provision x900-24
!
vlan database
 vlan 2-7 state enable
!
interface port1.0.1
 switchport
 switchport mode access
 access-group allow_to_self_10
 access-group access43
 access-group allow100_deny_private
!
interface port1.0.2
 switchport
 switchport mode access
 switchport access vlan 2
 access-group allow_to_self_20
 access-group access44
 access-group allow100_deny_private
!
interface port1.0.3
 switchport
 switchport mode access
 switchport access vlan 3
 access-group allow_to_self_30
 access-group access45
 access-group allow100_deny_private
!
interface port1.0.4-1.0.5
 switchport
 switchport mode access
```

```
 switchport access vlan 4
 access-group allow_to_self_40
 access-group access43
 access-group access44
 access-group access45
 access-group allow100_deny_private
!
interface port1.0.6-1.0.7
 switchport
 switchport mode access
 switchport access vlan 5
!
interface port1.0.8
 switchport
 switchport mode access
 switchport access vlan 6
!
interface port1.0.9
 switchport
 switchport mode access
 switchport access vlan 7
!
interface port1.0.10-1.0.24
 switchport
 switchport mode access
!
interface lo1
 ip address 1.1.1.1/32
!
interface lo2
 ip address 2.2.2.2/32
!
interface lo3
 ip address 3.3.3.3/32
!
interface lo4
 ip address 4.4.4.4/32
!
interface lo5
 ip address 5.5.5.5/32
!
interface lo6
 ip address 6.6.6.6/32
!
interface vlan1
 ip vrf forwarding red
 ip address 192.168.10.1/24
!
interface vlan2
 ip vrf forwarding green
 ip address 192.168.20.1/24
!
interface vlan3
 ip vrf forwarding blue
 ip address 192.168.30.1/24
!
interface vlan4
 ip vrf forwarding orange
 ip address 192.168.40.1/24
!
interface vlan5
 ip vrf forwarding shared
 ip address 192.168.100.1/24
!
```

```
interface vlan6
 ip vrf forwarding overlap
 ip address 192.168.10.1/24
!
interface vlan7
 ip vrf forwarding overlap
 ip address 192.168.50.1/24
!
router ospf 1 red
 network 192.168.10.0/24 area 0
 redistribute bgp
 default-information originate
!
router ospf 2 orange
 network 192.168.40.0/24 area 0
 redistribute static
 redistribute bgp
 default-information originate
!
router rip
 !
 address-family ipv4 vrf blue
 network 192.168.30.0/24
 redistribute bgp
 default-information originate
 exit-address-family
!
router bgp 100
 !
 address-family ipv4 vrf red
 redistribute connected
 redistribute ospf
 exit-address-family
 !
 address-family ipv4 vrf green
 redistribute connected
 neighbor 192.168.20.2 remote-as 100
 neighbor 192.168.20.2 next-hop-self
 neighbor 192.168.20.2 activate
 neighbor 192.168.20.2 default-originate
 exit-address-family
 !
 address-family ipv4 vrf blue
 redistribute connected
 redistribute rip
 exit-address-family
 !
 address-family ipv4 vrf orange
 redistribute connected
 redistribute static
 redistribute ospf
 exit-address-family
 !
 address-family ipv4 vrf shared
 redistribute connected
 redistribute static
 neighbor 192.168.100.254 remote-as 200
 neighbor 192.168.100.254 activate
 exit-address-family
!
ip route vrf red 0.0.0.0/0 192.168.100.254 vlan5
ip route vrf green 0.0.0.0/0 192.168.100.254 vlan5
ip route vrf blue 0.0.0.0/0 192.168.100.254 vlan5
ip route vrf orange 0.0.0.0/0 192.168.100.254 vlan5
```

```
ip route vrf orange 192.168.20.0/24 192.168.40.2
ip route vrf orange 192.168.140.0/24 192.168.40.2
ip route vrf shared 0.0.0.0/0 192.168.100.254
ip route vrf shared 192.168.43.0/24 192.168.100.2
ip route vrf shared 192.168.44.0/24 192.168.100.2
ip route vrf shared 192.168.45.0/24 192.168.100.2
!
route-map red43 permit 1
 match ip address redBlock4445
!
route-map green44 permit 1
 match ip address greenBlock4345
!
route-map blue45 permit 1
 match ip address blueBlock4344
!
route-map orange434445 permit 1
 match ip address orangeNoBlock
!
route-map orange140 permit 1
 match ip address orangeBlock20Export140
!
!
line con 0
line vty 0 4
!
end
```

IP route table from VRF device is below

```
awplus#show ip route
No entries in route table

[VRF: red]
Codes: C - connected, S - static, R - RIP, B - BGP
       O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       * - candidate default

Gateway of last resort is 192.168.100.254 to network 0.0.0.0

S*      0.0.0.0/0 [1/0] via 192.168.100.254, vlan5
C       1.1.1.1/32 is directly connected, lo1
B       5.5.5.5/32 [20/0] is directly connected, lo5, 00:07:21
C       192.168.10.0/24 is directly connected, vlan1
O       192.168.13.0/24 [110/2] via 192.168.10.2, vlan1, 00:06:27
O       192.168.14.0/24 [110/2] via 192.168.10.2, vlan1, 00:06:27
B       192.168.43.0/24 [20/0] via 192.168.100.2, vlan5, 00:07:17
B       192.168.100.0/24 [20/0] is directly connected, vlan5, 00:07:17

[VRF: green]
S*      0.0.0.0/0 [1/0] via 192.168.100.254, vlan5
C       2.2.2.2/32 is directly connected, lo2
B       5.5.5.5/32 [20/0] is directly connected, lo5, 00:07:21
B       192.168.15.0/24 [200/0] via 192.168.20.2, vlan2, 00:06:15
B       192.168.16.0/24 [200/0] via 192.168.20.2, vlan2, 00:06:14
C       192.168.20.0/24 is directly connected, vlan2
B       192.168.44.0/24 [20/0] via 192.168.100.2, vlan5, 00:07:17
B       192.168.100.0/24 [20/0] is directly connected, vlan5, 00:07:17
```

```
[VRF: blue]
S*      0.0.0.0/0 [1/0] via 192.168.100.254, vlan5
C       3.3.3.3/32 is directly connected, lo3
B       5.5.5.5/32 [20/0] is directly connected, lo5, 00:07:21
R       192.168.17.0/24 [120/2] via 192.168.30.2, vlan3, 00:06:48
R       192.168.18.0/24 [120/2] via 192.168.30.2, vlan3, 00:06:48
C       192.168.30.0/24 is directly connected, vlan3
B       192.168.45.0/24 [20/0] via 192.168.100.2, vlan5, 00:07:17
B       192.168.100.0/24 [20/0] is directly connected, vlan5, 00:07:17

[VRF: orange]
S*      0.0.0.0/0 [1/0] via 192.168.100.254, vlan5
C       4.4.4.4/32 is directly connected, lo4
B       5.5.5.5/32 [20/0] is directly connected, lo5, 00:07:20
O E2    192.168.19.0/24 [110/20] via 192.168.40.3, vlan4, 00:06:29
S       192.168.20.0/24 [1/0] via 192.168.40.2, vlan4
C       192.168.40.0/24 is directly connected, vlan4
B       192.168.43.0/24 [20/0] via 192.168.100.2, vlan5, 00:07:17
B       192.168.44.0/24 [20/0] via 192.168.100.2, vlan5, 00:07:17
B       192.168.45.0/24 [20/0] via 192.168.100.2, vlan5, 00:07:16
B       192.168.100.0/24 [20/0] is directly connected, vlan5, 00:07:17
S       192.168.140.0/24 [1/0] via 192.168.40.2, vlan4

[VRF: shared]
S*      0.0.0.0/0 [1/0] via 192.168.100.254, vlan5
B       1.1.1.1/32 [20/0] is directly connected, lo1, 00:07:21
B       2.2.2.2/32 [20/0] is directly connected, lo2, 00:07:21
B       3.3.3.3/32 [20/0] is directly connected, lo3, 00:07:21
B       4.4.4.4/32 [20/0] is directly connected, lo4, 00:07:21
C       5.5.5.5/32 is directly connected, lo5
B       192.168.10.0/24 [20/0] is directly connected, vlan1, 00:07:17
B       192.168.13.0/24 [20/2] via 192.168.10.2, vlan1, 00:06:26
B       192.168.14.0/24 [20/2] via 192.168.10.2, vlan1, 00:06:26
B       192.168.15.0/24 [200/0] via 192.168.20.2, vlan2, 00:06:15
B       192.168.16.0/24 [200/0] via 192.168.20.2, vlan2, 00:06:15
B       192.168.17.0/24 [20/2] via 192.168.30.2, vlan3, 00:06:47
B       192.168.18.0/24 [20/2] via 192.168.30.2, vlan3, 00:06:47
B       192.168.19.0/24 [20/20] via 192.168.40.3, vlan4, 00:06:28
B       192.168.20.0/24 [20/0] is directly connected, vlan2, 00:07:17
B       192.168.30.0/24 [20/0] is directly connected, vlan3, 00:07:17
B       192.168.40.0/24 [20/0] is directly connected, vlan4, 00:07:17
S       192.168.43.0/24 [1/0] via 192.168.100.2, vlan5
S       192.168.44.0/24 [1/0] via 192.168.100.2, vlan5
S       192.168.45.0/24 [1/0] via 192.168.100.2, vlan5
C       192.168.100.0/24 is directly connected, vlan5
B       192.168.140.0/24 [20/0] via 192.168.40.2, vlan4, 00:07:15

[VRF: overlap]
C       6.6.6.6/32 is directly connected, lo6
C       192.168.10.0/24 is directly connected, vlan6
C       192.168.50.0/24 is directly connected, vlan7
awplus#
```

Configuration files for each external router used in the topology and its associated route table is below. None of the external routers are VRF aware.

```
hostname Internet_router
!
vlan database
vlan 2 state enable
!
interface port1.0.2
 switchport access vlan 2
!
interface vlan1
 ip address 192.168.100.254/24
!
interface vlan2
 ip address 192.168.200.1/24
!
router bgp 200
 bgp router-id 192.168.200.1
 neighbor 192.168.100.1 remote-as 100
 neighbor 192.168.100.1 activate
!
ip route 0.0.0.0/0 192.168.200.254
!

Internet_router#show ip route
Codes: C - connected, S - static, R - RIP, B - BGP
       O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       * - candidate default

Gateway of last resort is 192.168.200.254 to network 0.0.0.0

S*      0.0.0.0/0 [1/0] via 192.168.200.254, vlan2
B       1.1.1.1/32 [20/0] via 192.168.100.1, vlan1, 00:09:30
B       2.2.2.2/32 [20/0] via 192.168.100.1, vlan1, 00:09:30
B       3.3.3.3/32 [20/0] via 192.168.100.1, vlan1, 00:09:30
B       4.4.4.4/32 [20/0] via 192.168.100.1, vlan1, 00:09:30
B       5.5.5.5/32 [20/0] via 192.168.100.1, vlan1, 00:09:30
B       192.168.10.0/24 [20/0] via 192.168.100.1, vlan1, 00:09:30
B       192.168.13.0/24 [20/0] via 192.168.100.1, vlan1, 00:09:30
B       192.168.14.0/24 [20/0] via 192.168.100.1, vlan1, 00:09:30
B       192.168.15.0/24 [20/0] via 192.168.100.1, vlan1, 00:09:30
B       192.168.16.0/24 [20/0] via 192.168.100.1, vlan1, 00:09:30
B       192.168.17.0/24 [20/0] via 192.168.100.1, vlan1, 00:09:30
B       192.168.18.0/24 [20/0] via 192.168.100.1, vlan1, 00:09:30
B       192.168.19.0/24 [20/0] via 192.168.100.1, vlan1, 00:09:30
B       192.168.20.0/24 [20/0] via 192.168.100.1, vlan1, 00:09:30
B       192.168.30.0/24 [20/0] via 192.168.100.1, vlan1, 00:09:30
B       192.168.40.0/24 [20/0] via 192.168.100.1, vlan1, 00:09:30
B       192.168.43.0/24 [20/0] via 192.168.100.2, vlan1, 00:09:30
B       192.168.44.0/24 [20/0] via 192.168.100.2, vlan1, 00:09:30
B       192.168.45.0/24 [20/0] via 192.168.100.2, vlan1, 00:09:30
C       192.168.100.0/24 is directly connected, vlan1
B       192.168.140.0/24 [20/0] via 192.168.100.1, vlan1, 00:09:30
C       192.168.200.0/24 is directly connected, vlan2
Internet_router#
```

```
hostname shared_router
!
vlan database
vlan 2-4 state enable
!
interface port1.0.2
 switchport access vlan 2
!
interface port1.0.3
 switchport access vlan 3
!
interface port1.0.4
 switchport access vlan 4
!
interface vlan1
 ip address 192.168.100.2/24
!
interface vlan2
 ip address 192.168.43.1/24
!
interface vlan3
 ip address 192.168.44.1/24
!
interface vlan4
 ip address 192.168.45.1/24
!
ip route 0.0.0.0/0 192.168.100.1
!

shared_router#show ip route
Codes: C - connected, S - static, R - RIP, B - BGP
       O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       * - candidate default

Gateway of last resort is 192.168.100.1 to network 0.0.0.0

S*      0.0.0.0/0 [1/0] via 192.168.100.1, vlan1
C       192.168.43.0/24 is directly connected, vlan2
C       192.168.44.0/24 is directly connected, vlan3
C       192.168.45.0/24 is directly connected, vlan4
C       192.168.100.0/24 is directly connected, vlan1
shared_router#
```

```
hostname red_ospf_peer
!
vlan database
vlan 2-3 state enable
!
interface port1.0.2
 switchport access vlan 2
!
interface port1.0.3
 switchport access vlan 3
!
interface vlan1
 ip address 192.168.10.2/24
!
interface vlan2
 ip address 192.168.13.1/24
!
interface vlan3
 ip address 192.168.14.1/24
!
router ospf 1
 ospf router-id 192.168.10.2
 network 192.168.10.0/24 area 0
 redistribute connected
!

red_ospf_peer#show ip route
Codes: C - connected, S - static, R - RIP, B - BGP
       O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       * - candidate default

Gateway of last resort is 192.168.10.1 to network 0.0.0.0

O*E2    0.0.0.0/0 [110/10] via 192.168.10.1, vlan1, 00:00:07
O E2    5.5.5.5/32 [110/1] via 192.168.10.1, vlan1, 00:00:07
C       192.168.10.0/24 is directly connected, vlan1
C       192.168.13.0/24 is directly connected, vlan2
C       192.168.14.0/24 is directly connected, vlan3
O E2    192.168.43.0/24 [110/1] via 192.168.10.1, vlan1, 00:00:07
O E2    192.168.100.0/24 [110/1] via 192.168.10.1, vlan1, 00:00:07
red_ospf_peer#
```

```
hostname green_i_BGP_peer
!
vlan database
vlan 2-3 state enable
!
interface port1.0.2
 switchport access vlan 2
!
interface port1.0.3
 switchport access vlan 3
!
interface vlan1
 ip address 192.168.20.2/24
!
interface vlan2
 ip address 192.168.15.1/24
!
interface vlan3
 ip address 192.168.16.1/24
!
router bgp 100
 bgp router-id 192.168.20.2
 redistribute connected
 neighbor 192.168.20.1 remote-as 100
 neighbor 192.168.20.1 activate
!

green_i_bgp_peer#show ip route
Codes: C - connected, S - static, R - RIP, B - BGP
       O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       * - candidate default

Gateway of last resort is 192.168.20.1 to network 0.0.0.0

B*      0.0.0.0/0 [200/0] via 192.168.20.1, vlan1, 00:02:58
B       2.2.2.2/32 [200/0] via 192.168.20.1, vlan1, 00:02:58
B       5.5.5.5/32 [200/0] via 192.168.20.1, vlan1, 00:02:58
C       192.168.15.0/24 is directly connected, vlan2
C       192.168.16.0/24 is directly connected, vlan3
C       192.168.20.0/24 is directly connected, vlan1
B       192.168.44.0/24 [200/0] via 192.168.20.1, vlan1, 00:02:58
B       192.168.100.0/24 [200/0] via 192.168.20.1, vlan1, 00:02:58
green_i_BGP_peer#
```

```
hostname blue_rip_peer
!
vlan database
vlan 2-3 state enable
!
interface port1.0.2
 switchport access vlan 2
!
interface port1.0.3
 switchport access vlan 3
!
interface vlan1
 ip address 192.168.30.2/24
!
interface vlan2
 ip address 192.168.17.1/24
!
interface vlan3
 ip address 192.168.18.1/24
!
router rip
 network 192.168.30.0/24
 redistribute connected
!

blue_rip_peer#show ip route
Codes: C - connected, S - static, R - RIP, B - BGP
       O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       * - candidate default

Gateway of last resort is 192.168.30.1 to network 0.0.0.0

R*      0.0.0.0/0 [120/2] via 192.168.30.1, vlan1, 00:00:02
R       5.5.5.5/32 [120/2] via 192.168.30.1, vlan1, 00:00:02
C       192.168.17.0/24 is directly connected, vlan2
C       192.168.18.0/24 is directly connected, vlan3
C       192.168.30.0/24 is directly connected, vlan1
R       192.168.45.0/24 [120/2] via 192.168.30.1, vlan1, 00:00:02
R       192.168.100.0/24 [120/2] via 192.168.30.1, vlan1, 00:00:02
blue_rip_peer#
```

```
hostname orange_router
!
vlan database
vlan 2-3 state enable
!
interface port1.0.2
 switchport access vlan 2
!
interface port1.0.3
 switchport access vlan 3
!
interface vlan1
 ip address 192.168.40.2/24
!
interface vlan2
 ip address 192.168.20.1/24
!
interface vlan3
 ip address 192.168.140.1/24
!
ip route 0.0.0.0/0 192.168.40.1
!

orange_router#show ip route
Codes: C - connected, S - static, R - RIP, B - BGP
       O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       * - candidate default

Gateway of last resort is 192.168.40.1 to network 0.0.0.0

S*      0.0.0.0/0 [1/0] via 192.168.40.1, vlan1
C       192.168.20.0/24 is directly connected, vlan2
C       192.168.40.0/24 is directly connected, vlan1
C       192.168.140.0/24 is directly connected, vlan3
orange_router#
```

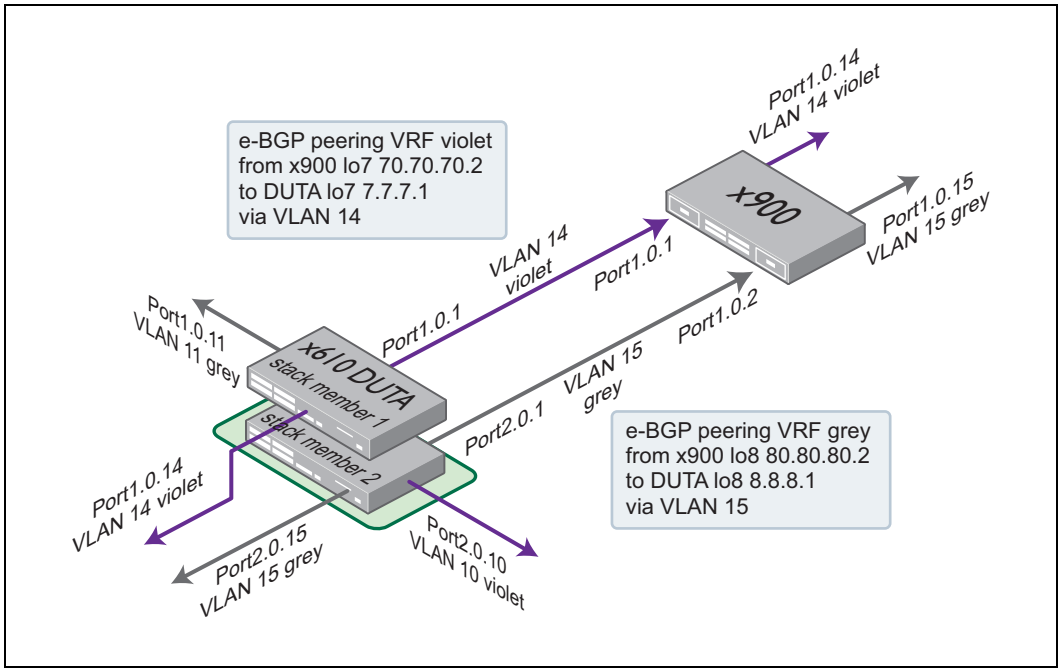
```
hostname orange_ospf_peer
!
vlan database
vlan 2 state enable
!
interface port1.0.2
 switchport access vlan 2
!
interface vlan1
 ip address 192.168.40.3/24
!
interface vlan2
 ip address 192.168.19.1/24
!
router ospf 1
 ospf router-id 192.168.40.3
 network 192.168.40.0/24 area 0
 redistribute connected
!
orange_ospf_peer# show ip route
Codes: C - connected, S - static, R - RIP, B - BGP
       O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       * - candidate default

Gateway of last resort is 192.168.40.1 to network 0.0.0.0

O*E2    0.0.0.0/0 [110/10] via 192.168.40.1, vlan1, 00:05:34
O E2    5.5.5.5/32 [110/1] via 192.168.40.1, vlan1, 00:05:34
C       192.168.19.0/24 is directly connected, vlan2
O E2    192.168.20.0/24 [110/20] via 192.168.40.2, vlan1, 00:05:34
C       192.168.40.0/24 is directly connected, vlan1
O E2    192.168.43.0/24 [110/1] via 192.168.40.1, vlan1, 00:05:34
O E2    192.168.44.0/24 [110/1] via 192.168.40.1, vlan1, 00:05:34
O E2    192.168.45.0/24 [110/1] via 192.168.40.1, vlan1, 00:05:34
O E2    192.168.100.0/24 [110/1] via 192.168.40.1, vlan1, 00:05:34
O E2    192.168.140.0/24 [110/20] via 192.168.40.2, vlan1, 00:05:34
orange_ospf_peer#
```

VCStack and VRF-lite

The following example illustrates how to configure VRF-lite in a VCStacked environment.

In the example below, each port from the x900 connects to a different x610 VCStack member. Each port also belongs to a different VRF domain.

E-BGP peering between IP local addresses is used between the x900 and x610 VCStack members on a per VRF basis - in order for the x900 device to learn routes to x610 subnets associated with each VRF.



Other features used in this configuration

In the configuration below, you will notice a couple of features in use that have not been previously discussed, namely stack provisioning and virtual-chassis ID.

Stack provisioning

Provisioning provides the ability to pre-configure a switch for stacking.

With provisioning, you can configure stack members and their ports, even though they are not currently physically present, and configure them ready for future addition to the stack. This means that you can either pre-configure ports belonging to a switch that has not yet been installed, or load a configuration that references these ports.

For example:

```
switch 1 provision x610-48
switch 2 provision x610-48
```

Note: You can only stack, and therefore provision, switches of the same basic model.

Virtual Chassis ID

Also, the optional command **stack virtual-chassis-id <value>** specifies the VCS virtual chassis ID.

If not configured, the stack will automatically select a virtual-chassis-id from a number within the assigned range 0-4095. The ID selected will determine which virtual MAC address the stack will automatically use. The MAC address assigned to a stack must be unique within its network.

For more information about VCStack, refer to http://www.alliedtelesis.com/media/fount/how_to_note_alliedware_plus/overview_aw_plus__stacking_REVD.pdf.

X610 VCStack configuration

```
!
hostname DUTA
!
stack virtual-chassis-id 2034
!
ip vrf violet 7
 rd 100:7
!
ip vrf grey 8
 rd 100:8
!
switch 1 provision x610-48
switch 2 provision x610-48
!
vlan database
 vlan 10-11,14-15 state enable
!
interface port1.0.1
 switchport access vlan 14
!
interface port1.0.11
 switchport access vlan 11
!
interface port1.0.14
 switchport access vlan 14
!
interface port2.0.1
 switchport access vlan 15
!
interface port2.0.10
 switchport access vlan 10
!
interface port2.0.15
 switchport access vlan 15
!
interface lo7
 ip address 7.7.7.1/32
!
interface lo8
 ip address 8.8.8.1/32
!
interface vlan10
 ip vrf forwarding violet
 ip address 10.10.10.1/24
!
interface vlan11
 ip vrf forwarding grey
```

```
 ip address 11.11.11.1/24
!
interface vlan14
 ip vrf forwarding violet
 ip address 192.168.14.1/24
!
interface vlan15
 ip vrf forwarding grey
 ip address 192.168.15.1/24
!
router bgp 100
 !
 address-family ipv4 vrf violet
 redistribute connected
 neighbor 70.70.70.2 remote-as 300
 neighbor 70.70.70.2 ebgp-multihop 2
 neighbor 70.70.70.2 update-source lo7
 neighbor 70.70.70.2 activate
 exit-address-family
 !
 address-family ipv4 vrf grey
 redistribute connected
 neighbor 80.80.80.2 remote-as 300
 neighbor 80.80.80.2 ebgp-multihop 2
 neighbor 80.80.80.2 update-source lo8
 neighbor 80.80.80.2 activate
 exit-address-family
!
ip route vrf violet 70.70.70.2/32 192.168.14.2
ip route vrf grey 80.80.80.2/32 192.168.15.2
!
```

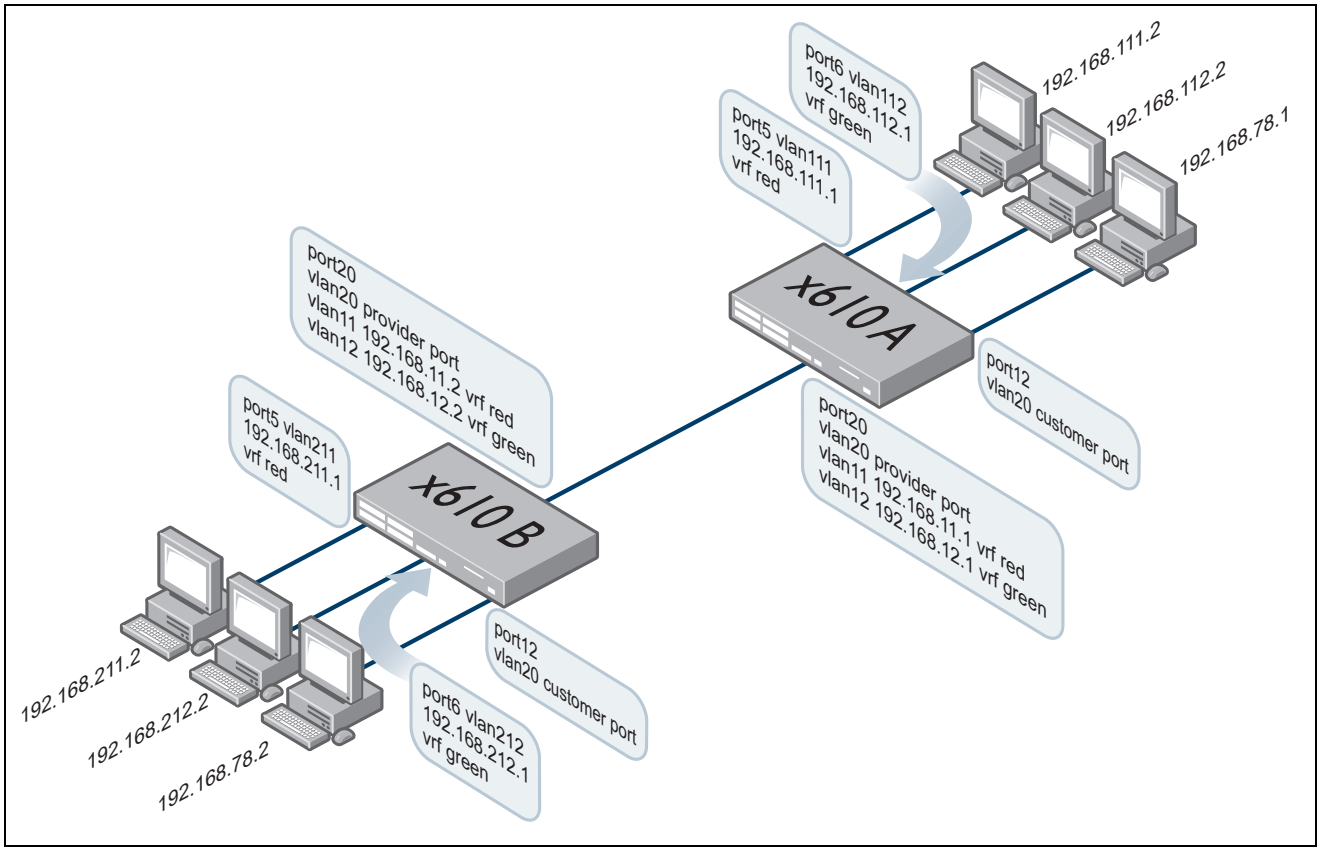
x900 configuration

```
!
hostname x900
!
ip vrf violet 7
 rd 300:7
!
ip vrf grey 8
 rd 300:8
!
vlan database
 vlan 14-15 state enable
!
interface port1.0.1
 switchport access vlan 14
!
interface port1.0.2
 switchport access vlan 15
!
interface port1.0.14
 switchport access vlan 14
!
interface port1.0.15
 switchport access vlan 15
!
interface lo7
 ip address 70.70.70.2/32
!
interface lo8
 ip address 80.80.80.2/32
```

```
!
interface vlan14
 ip vrf forwarding violet
 ip address 192.168.14.2/24
!
interface vlan15
 ip vrf forwarding grey
 ip address 192.168.15.2/24
!
router bgp 300
 !
 address-family ipv4 vrf grey
 network 80.80.80.2/32
 redistribute connected
 neighbor 8.8.8.1 remote-as 100
 neighbor 8.8.8.1 ebgp-multihop 2
 neighbor 8.8.8.1 update-source lo8
 neighbor 8.8.8.1 activate
 exit-address-family
 !
 address-family ipv4 vrf violet
 network 70.70.70.2/32
 redistribute connected
 neighbor 7.7.7.1 remote-as 100
 neighbor 7.7.7.1 ebgp-multihop 2
 neighbor 7.7.7.1 update-source lo7
 neighbor 7.7.7.1 activate
 exit-address-family
!
ip route vrf violet 7.7.7.1/32 192.168.14.1
ip route vrf grey 8.8.8.1/32 192.168.15.1
!
```

Sharing VRF routing and double tagging on the same port

In this scenario, both VRF-lite traffic and double vlan tagged traffic is transported between the two x610 switches via a single shared port. The double tagging feature (nested vlans) makes use of the tag-in-tag technique. The inner tag comes from the end hosts whilst the outer tag is configured in the x610 switches. VRF-lite traffic remains separated from the double vlan tagged traffic.



Communication plan

- Host 192.168.111.2 A can communicate with host 192.168.211.2 by VRF red routing.
- Host 192.168.112.2 A can communicate with host 192.168.212.2 by VRF green routing.
- Host 192.168.78.1 can communicate with host 192.168.78.2 by double tagging. When Ethernet frames enter the customer edge port, the switch adds an outer vlan tag (VID 20) on top of the customer inner vlan tag. Ethernet frames can also be sent untagged from the hosts. The customer VID (inner tag) is ignored whilst the frames are bridged between the two x610 switches. As Ethernet frames exit the customer edge port of the destination switch, the outer tag is removed. Therefore, when the packets exit the customer port, the original VLAN tags (or untagged Ethernet frames) are preserved.

Configurations

x610 A

```
ip vrf red 1
ip vrf green 2

vlan database
 vlan 20 name nested
 vlan 11-12,20,111-112 state enable

interface port1.0.5
switchport access vlan 111

interface port1.0.6
switchport access vlan 112

interface port1.0.12
switchport access vlan 20
 switchport vlan-stacking customer-edge-port

interface port1.0.20
switchport mode trunk
switchport trunk allowed vlan add 11-12,20
 switchport trunk native vlan none
 switchport vlan-stacking provider-port

interface vlan11
 ip vrf forwarding red
 ip address 192.168.11.1/24

interface vlan12
 ip vrf forwarding green
 ip address 192.168.12.1/24

interface vlan111
 ip vrf forwarding red
 ip address 192.168.111.1/24

interface vlan112
 ip vrf forwarding green
 ip address 192.168.112.1/24

ip route vrf red 192.168.211.0/24 192.168.11.2
ip route vrf green 192.168.212.0/24 192.168.12.2
```

x610 B

```
ip vrf red 1
ip vrf green 2

vlan database
 vlan 20 name nested
vlan 11-12,20,111-112 state enable

interface port1.0.5
switchport access vlan 111

interface port1.0.6
switchport access vlan 112

interface port1.0.12
switchport access vlan 20
 switchport vlan-stacking customer-edge-port
```

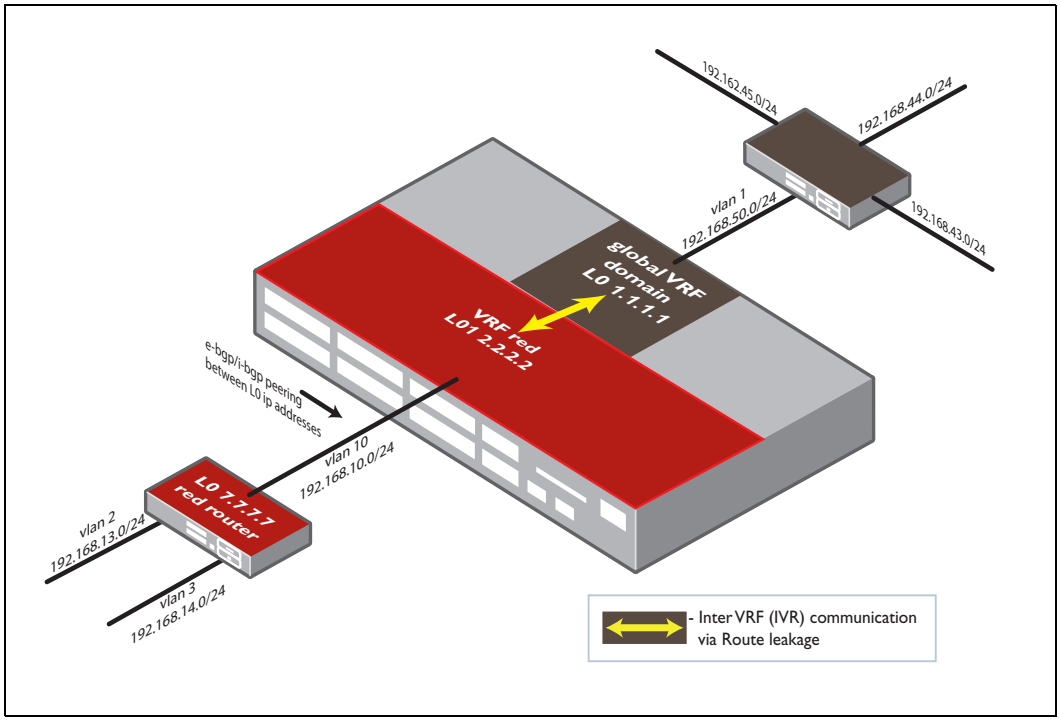
```
interface port1.0.20
switchport mode trunk
 switchport trunk allowed vlan add 11-12,20
 switchport trunk native vlan none
 switchport vlan-stacking provider-port

interface vlan11
 ip vrf forwarding red
 ip address 192.168.11.2/24

interface vlan12
 ip vrf forwarding green
 ip address 192.168.12.2/24

interface vlan111
 ip vrf forwarding red
 ip address 192.168.211.1/24

interface vlan112
 ip vrf forwarding green
 ip address 192.168.212.1/24

ip route vrf red 192.168.111.0/24 192.168.11.1
ip route vrf green 192.168.112.0/24 192.168.12.1
```

Dynamic inter-VRF routing between the global VRF domain and a VRF instance

This section contains two configuration examples. Both examples show how to configure dynamic inter-VRF routing via BGP between the default global VRF domain and VRF red. Both examples use the same topology as described in the drawing below. The first example includes i-BGP peering to the external red router. The second example includes e-BGP peering to the external red router. Both examples involve leaking BGP routes between the global VRF domain and VRF red, and subsequently to the external red router.

To achieve dynamic inter-VRF routing between the default global VRF domain and a VRF instance, an internal e-BGP neighbor relationship is formed between the global VRF domain and VRF red using the BGP **remote-as** and **local-as** commands.

The internal e-BGP peering relationship is only used when performing inter-VRF route leakage from the default global VRF domain to a VRF instance.



Additional notes

In addition, route maps are referenced by BGP, to filter selective routes advertised to each VRF instance from the global VRF domain.

The first example involves leaking routes from default global VRF domain to VRF red (internally via e-BGP), and subsequently to an external i-BGP neighbor (red router) and vice-versa.

The second example involves leaking routes from default global VRF domain to VRF red (internally via e-BGP), and subsequently to an e-BGP neighbor (red router) and vice-versa.

For both these examples all BGP neighbor relationships involve peering between IP local addresses, not to VLAN interface IP addresses within the same subnet.

BGP configuration tips

The following BGP configuration tips are included to explain the use of some BGP specific commands used in the i-BGP and e-BGP example configuration files below.

neighbor x.x.x.x update-source lo

The command **neighbor x.x.x.x** update-source lo is used to ensure the lo is used as the update source when establishing the BGP neighbor relationship instead of the egress VLAN interface IP.

neighbor x.x.x.x ebgp-multihop 2

The command **neighbor x.x.x.x ebgp-multihop 2** is not applicable for an i-BGP connection, but is required for e-BGP when peering to an IP address in a remote network. For example, when forming an e-BGP neighbor relationship to the IP local address configured in a remote peer, the command is required.

This command above, is automatically generated when using e-BGP peering in conjunction with the **neighbor x.x.x.x update-source** command. The command defaults to hop count of 2 when automatically generated, but it can be explicitly configured to allow e-BGP peering to devices up to 255 hops away.

I-BGP doesn't default to peers being in the same subnet, as it supports multi-hop automatically. This is because the default configuration of i-BGP is a full mesh of all the routers in the AS and there's no expectation that all i-BGP peers within the mesh will be in the same subnet. So, unlike e-BGP it can be quite common for an i-BGP TCP connection to be formed to IP address in a remote network, instead of peering to an IP address in same subnet.

In the case of e-BGP, it is uncommon to peer to a local loopback address, and similarly, the connection is not typically via a multi-hop L3 routed path - and the concept of a full mesh between all peers doesn't apply. Hence e-BGP defaults to not allowing peering beyond a single hop.

neighbor x.x.x.x next-hop-self

I-BGP does not change the next hop address contained in BGP routes. To get i-BGP to change the nexthop IP, you need to use the **neighbor x.x.x.x next-hop-self** command.

neighbor x.x.x.x route-map <xx> out

The command **neighbor x.x.x.x route-map <xx>** out is used to reference and apply a route map. The route map in turn references an access-list. The **out** parameter in the command **neighbor x.x.x.x route-map <xx> out** specifies that the access list (used to filter routes), applies to outgoing advertisements.

The **global** parameter in the command **neighbor x.x.x.x remote-as <64515> global** is required to facilitate an e-BGP peering to the global VRF domain from VRF red.

Conversely, the target **vrf-name** in the command **neighbor x.x.x.x remote-as <64512> vrf <red>** is required to be configured to facilitate an e-BGP peering to VRF red from the global VRF domain.

Additionally, the global VRF domain contains remote-as 64512, and local-as 64515 to ensure e-BGP is used for internal peering to VRF red.

Conversely, VRF red contains remote-as 64515, and local-as 64512 to ensure e-BGP is used for internal peering to the global VRF domain.

Dynamic inter-VRF communication with i-BGP routing to external peer

VRF device

```
access-list standard redblock4445 deny 192.168.44.0/24
access-list standard redblock4445 deny 192.168.45.0/24
access-list standard redblock4445 permit any
!
ip vrf red 1
rd 100:1
!
vlan database
vlan 10 state enable
!
interface port1.0.3
switchport access vlan 10
!
interface lo
ip address 1.1.1.1/32
!
interface lo1
ip address 2.2.2.2/32
!
interface vlan1
ip address 192.168.50.1/24
!
interface vlan10
ip vrf forwarding red
ip address 192.168.10.1/24
!
router bgp 100
redistribute connected
redistribute static
neighbor 2.2.2.2 remote-as 64512 vrf red
neighbor 2.2.2.2 local-as 64515
neighbor 2.2.2.2 update-source 1.1.1.1
neighbor 2.2.2.2 route-map 43 out
!
address-family ipv4 vrf red
redistribute connected
redistribute static
neighbor 1.1.1.1 remote-as 64515 global
neighbor 1.1.1.1 local-as 64512
neighbor 1.1.1.1 update-source lo1
neighbor 1.1.1.1 activate
neighbor 7.7.7.7 remote-as 100
neighbor 7.7.7.7 update-source lo1
neighbor 7.7.7.7 activate
neighbor 7.7.7.7 next-hop-self
exit-address-family
!
ip route 2.2.2.2/32 lo1
ip route 192.168.43.0/24 192.168.50.2
ip route 192.168.44.0/24 192.168.50.2
ip route 192.168.45.0/24 192.168.50.2
ip route vrf red 1.1.1.1/32 lo
ip route vrf red 7.7.7.7/32 192.168.10.2
!
route-map 43 permit 1
 match ip address redblock4445
```

```
red router
vlan database
vlan 2-3 state enable
!
interface port1.0.13
switchport access vlan 2
!
interface port1.0.14
switchport access vlan 3
!
interface lo
ip address 7.7.7.7/32
!
interface vlan1
ip address 192.168.10.2/24
!
interface vlan2
ip address 192.168.13.1/24
!
interface vlan3
ip address 192.168.14.1/24
!
router bgp 100
redistribute connected
redistribute static
neighbor 2.2.2.2 remote-as 100
neighbor 2.2.2.2 update-source lo
!
ip route 2.2.2.2/32 192.168.10.1
ip route 172.16.50.0/24 192.168.13.2
ip route 172.16.55.0/24 192.168.14.2
!
```

Dynamic inter-VRF communication with e-BGP routing to external peer

```
access-list standard redblock4445 deny 192.168.44.0/24
access-list standard redblock4445 deny 192.168.45.0/24
access-list standard redblock4445 permit any
!
ip vrf red 1
rd 100:1
!
vlan database
vlan 10 state enable
!
interface port1.0.3
switchport access vlan 10
!
interface lo
ip address 1.1.1.1/32
!
interface lo1
ip address 2.2.2.2/32
!
interface vlan1
ip address 192.168.50.1/24
!
interface vlan10
ip vrf forwarding red
ip address 192.168.10.1/24
!
router bgp 100
```

```
redistribute connected
redistribute static
neighbor 2.2.2.2 remote-as 64512 vrf red
neighbor 2.2.2.2 local-as 64515
neighbor 2.2.2.2 update-source 1.1.1.1
neighbor 2.2.2.2 route-map 43 out
!
address-family ipv4 vrf red
redistribute connected
redistribute static
neighbor 1.1.1.1 remote-as 64515 global
neighbor 1.1.1.1 local-as 64512
neighbor 1.1.1.1 update-source lo1
neighbor 1.1.1.1 activate
neighbor 7.7.7.7 remote-as 300
neighbor 7.7.7.7 ebgp-multihop 2
neighbor 7.7.7.7 update-source lo1
neighbor 7.7.7.7 activate
exit-address-family
!
ip route 2.2.2.2/32 lo1
ip route 192.168.43.0/24 192.168.50.2
ip route 192.168.44.0/24 192.168.50.2
ip route 192.168.45.0/24 192.168.50.2
ip route vrf red 1.1.1.1/32 lo
ip route vrf red 7.7.7.7/32 192.168.10.2
!
route-map 43 permit 1
 match ip address redblock4445
```

red router

```
!
vlan database
vlan 2-3 state enable
!
interface port1.0.13
switchport access vlan 2
!
interface port1.0.14
switchport access vlan 3
!
interface lo
ip address 7.7.7.7/32
!
interface vlan1
ip address 192.168.10.2/24
!
interface vlan2
ip address 192.168.13.1/24
!
interface vlan3
ip address 192.168.14.1/24
!
router bgp 300
redistribute connected
redistribute static
neighbor 2.2.2.2 remote-as 100
neighbor 2.2.2.2 ebgp-multihop 255
neighbor 2.2.2.2 update-source lo
!
ip route 2.2.2.2/32 192.168.10.1
ip route 172.16.50.0/24 192.168.13.2
ip route 172.16.55.0/24 192.168.14.2
!
```

Route Limits

In multi-VRF network environment, it may be disastrous if one VRF injects too many routes and fills up the hardware forwarding table (FIB) on a device which can affect other VRFs (as well as the global VRF).

In software version 5.4.2 and later, it is possible to mitigate this risk, as route limits can now be configured on a per VRF basis.

Existing AW+ commands **max-static-routes** and **max-fib-routes** have been extended in 5.4.2 to allow configurable static and dynamic route limits on a per VRF instance basis.

Note: The command **max-fib-routes** only counts dynamic routes (not including static and connected routes).

Note: By default, there is no preset allocation of the number of route table entries available to each VRF instance. When static and/or dynamic VRF instances are configured (without setting limits via the commands **max-static-routes** and **max-fib-routes**), the number of route table entries available to each VRF instance are not automatically reserved.

Configuring static route limits

AW+ supports the ability to limit static routes via the **max-static-routes** command in the global VRF domain, with a default maximum limit of 1000 (routes). This same AW+ command is now also able to be applied on a per VRF basis.

Static route limits can be applied as part of VRF Configuration Mode via the command:

```
awplus(vrf-config)# max-static-routes <1-1000>
```

The following example shows how to configure a limit of 200 static routes, applied to VRF red:

```
awplus(config)# ip vrf red
awplus(config-vrf)# max-static-routes 200
```

Note: Static routes limits are applied before adding routes to the **RIB**. Rejected static routes will not be in the running config.

Configuring Dynamic route limits

AW+ supports the ability to limit dynamic routes via the **max-fib-routes** command in the global VRF domain, which is unlimited by default. This same AW+ command is now also able to be applied on a per VRF basis.

max-fib-routes

Description

Use the command **max-fib-routes** to set the maximum number of dynamic routes in FIB (Forwarding Information Base). Static and Connected routes are not included. Dynamic routes to be added to the HW FIB table that exceed the configured limit are rejected.

When an additional threshold value (in percentage) is configured, a warning message is generated if the number of dynamic routes in the FIB exceeds the threshold, and the routes exceeding the limit are rejected.If warning-only is specified, routes are still allowed to be added, but a warning message is generated when the threshold is reached.

When this command is executed in VRF Configuration mode, it sets the maximum number of dynamic routes that can be added to the HW FIB table associated with the VRF instance.

Command Syntax

```
max-fib-routes <1-4294967294> (<1-100>|warning-only|)
```

PARAMETER	DESCRIPTION
max-fib-routes	Set maximum fib routes number
<1- 4294967294>	Allowed number of fib routes excluding Connect and Static
<1-100>	Warning threshold in percentage
warning-only	Allow to add more routes than the limit but with warning message

Default

By default, the maximum number of dynamic routes is 4294967294 and no warning threshold is set.

Command Level

PROMPT	MODE	PRIVILEGE LEVEL
(config)	CONFIG_MODE	PRIVILEGE_MAX
(config-vrf)	VRF_MODE	PRIVILEGE_VR_MAX

Warning thresholds (percentage) can be configured for dynamic route limits.

```
awplus(vrf-config)# max-fib-routes <1-4294967294> WARNING-
THRESHOLD%
```

Examples

To set the maximum number of dynamic routes to 2000 and warning threshold with 75%, applied to VRF red HW FIB, configure the following:

```
awplus(config)# ip vrf red
awplus(config-vrf)# max-fib-routes 2000 75
```

Alternatively, to ensure a warning message is generated when the number of routes exceeds the limit (whilst ensuring routes exceeding the limit can still be added), configure the following:

```
awplus(config)# ip vrf red
awplus(vrf-config)# max-fib-routes <1-4294967294> warning-only
```

Note: Dynamic limits routes are applied before adding routes to the **FIB**. All routes, including rejected dynamic routes can be displayed via the command **show ip route database**.

See Also
```
max-fib-routes
no max-fib-routes
show ip route
```

no max-fib-routes

Description Use this command to reset the maximum number of dynamic routes in FIB.

When this command is executed in VRF Configuration mode, it sets the maximum number of dynamic routes that can be added to the HW FIB table associated with the VRF instance.

Command Syntax
```
no max-fib-routes
```

PARAMETER	DESCRIPTION
no	Negate a command or set its defaults
max-fib-routes	Set maximum fib routes number

Default By default, the maximum number of dynamic routes is 4294967294 and no warning threshold is set.

Command Level

PROMPT	MODE	PRIVILEGE LEVEL
(config)	CONFIG_MODE PRIVILEGE_MAX	PRIVILEGE_MAX
(config-vrf)	VRF_MODE PRIVILEGE_VR_MAX	PRIVILEGE_VR_MAX

See Also
```
max-fib-routes
show ip route
```

VRF-lite usage guidelines

The general guideline is that all current services remain available in the default global VRF domain only, unless the service is either explicitly VRF aware, or the service runs completely independently of VRF and therefore has no requirement to be VRF aware.

VRF-LITE SPECIFIC GUIDELINES
■ Utility services such as TFTP, SNMP, SSH server, telnet server, system log, file copy, DHCP relay, DHCP server, DHCP snooping, NTP server are not VRF aware and remain available in the global VRF domain only.
■ VRF-lite is supported for IPv4 unicast and broadcast traffic only. L2 and L3 multicast services, including IGMP snooping, IGMP querier, IGMP proxy, PIM remain available via the global VRF domain only.
■ IPv6 routing protocols are not VRF aware and remain available in the global VRF domain only.
■ SNMP and syslog services remain available via the global VRF domain only.
■ In the case of Nested VLANs (VLAN double tagging), all VLANs (and associated switch ports) must be a member of the global VRF domain only.
■ GVRP is not supported in conjunction with VRF-lite.
■ QoS services remain available via the global VRF domain only.
■ Subnet-based VLAN classification is not supported in conjunction with VRF-lite.
■ All private VLANs must be a member of the global VRF domain only.
■ 802.1Q trunked links are able to span multiple VRF instances with the x610 product only. ■ 802.1Q trunked links are not able to span multiple VRF instances with x900 series switch and the Switchblade x908 switch - all VLANs associated with an 802.1Q trunked link must exist within a single VRF instance for these products.
■ All data VLANs and associated control VLAN associated with an EPSR domain must exist within the same VRF instance. For example, EPSR data VLAN(s) cannot reside in a different VRF instance than the associated control VLAN for an EPSR domain.
■ Both RSTP or MSTP can be used in conjunction with VRF. VLANs associated with an MSTP instance should exist within same VRF instance.
■ 802.1x authentication services remain available via the global VRF domain only.
■ VRRP instances continue to operate on a per port basis - VRRP monitored interfaces defined in a VRRP instance should exist within the same VRF instance as the VRRP instance.
■ Filtering services (routemaps, access groups, ACLs) continue to work independently of VRF-lite.
■ Static aggregation and LACP continue to work independently of VRF-lite.
■ LLDP continues to work independently of VRF-lite.

Useful VRF-related diagnostics command list

Below is a summary list of diagnostics commands that you may find helpful when troubleshooting VRF-related issues. Many existing commands have been made VRF aware and some are included below. Please refer to the software reference manual for a complete list of VRF aware commands.

General

```
awplus#show tech-support
awplus#show running-config
awplus#show running-config vrf
awplus#show system
awplus#show boot
awplus#show clock
awplus#show license
```

VRF

```
awplus#show ip vrf
awplus#show ip vrf ?
  WORD       VRF instance name
  brief      Brief VRF instance information
  detail     Detailed VRF instance information
  interface  Interface information
  |          Output modifiers
  >          Output redirection
  >>         Output redirection (append)
  <cr>
awplus#show ip vrf interface
awplus#show ip vrf detail
```

Routing general

```
awplus#show ip route
(selected routes listed for each VRF)
Codes: C - connected, S - static, R - RIP, B - BGP
       O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       * - candidate default

[VRF: <VRFname A>]
[VRF: <VRFnameB>]
[VRF: <VRFnameC>]

awplus#show ip route database

(complete route table database listed for each VRF)

Codes: C - connected, S - static, R - RIP, B - BGP
       O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       * - candidate default

[VRF: <VRFname A>]
[VRF: <VRFnameB>]
[VRF: <VRFnameC>]

awplus#show ip route ?
  A.B.C.D    Network in the IP routing table to display
  A.B.C.D/M  IP prefix <network>/<length>, e.g., 35.0.0.0/8
  bgp        Border Gateway Protocol (BGP)
```

```
  connected  Connected
  database   IP routing table database
  global     Global Routing/Forwarding table
  ospf       Open Shortest Path First (OSPF)
  rip        Routing Information Protocol (RIP)
  static     Static routes
  summary    Summary of all routes
  vrf        Display routes from a VRF instance
  |          Output modifiers
  >          Output redirection
  >>         Output redirection (append)
  <cr>

awplus#show ip route vrf <name>

awplus#show ip route vrf <name> ?
  bgp        Border Gateway Protocol (BGP)
  connected  Connected
  database   IP routing table database
  ospf       Open Shortest Path First (OSPF)
  rip        Routing Information Protocol (RIP)
  static     Static routes
  |          Output modifiers
  >          Output redirection
  >>         Output redirection (append)
  <cr>
```

Routing protocols

```
awplus#show ip rip
(rip routes listed for each VRF)

awplus#show ip rip vrf <name> ?
  database   IP RIP database
  interface  IP RIP interface status and configuration
  |          Output modifiers
  >          Output redirection
  >>         Output redirection (append)
  <cr>

awplus#show ip rip database

awplus#sh ip rip database full
(complete rip routes database listed for each VRF)

awplus#show ip rip vrf <name> ?
  database   IP RIP database
  interface  IP RIP interface status and configuration
  |          Output modifiers
  >          Output redirection
  >>         Output redirection (append)
  <cr>

awplus#show ip ospf
awplus#show ip ospf neighbor
(neighbor information lisyed by OSPF process ID - each OSPF process is
associated with a VRF instance)

OSPF process 1:
Neighbor ID     Pri   State           Dead Time   Address         Interface
OSPF process 2:
Neighbor ID     Pri   State           Dead Time   Address         Interface
```

```
awplus#sh ip ospf interface

awplus#sh ip ospf ?
  <0-65535>       Process ID number
  border-routers  Border and Boundary Router Information
  database        Database summary
  interface       Interface information
  neighbor        Neighbor list
  route           OSPF routing table
  virtual-links   Virtual link information
  |               Output modifiers
  >               Output redirection
  >>              Output redirection (append)
  <cr>

awplus#sh ip ospf 1
awplus#sh ip ospf 1 ?
  border-routers  Border and Boundary Router Information
  database        Database summary
  neighbor        Neighbor list
  route           OSPF routing table
  virtual-links   Virtual link information
  |               Output modifiers
  >               Output redirection
  >>              Output redirection (append)
  <cr>

awplus#show ip ospf 1 neighbor

awplus#show ip bgp

[VRF: <VRFnameA list>]
[VRF: <VRFnameB list>]

awplus#show ip bgp ?
  A.B.C.D          IP prefix <network>, e.g., 35.0.0.0
  A.B.C.D/M        IP prefix <network>/<length>, e.g., 35.0.0.0/8
  attribute-info   List all bgp attribute information
  cidr-only        Display only routes with non-natural netmasks
  community        Display routes matching the communities
  community-info   List all bgp community information
  community-list   Display routes matching the community-list
  dampening        Display detailed information about dampening
  defer-delete     peer defer delete status
  filter-list      Display routes conforming to the filter-list
  global           Global Routing/Forwarding table
  inconsistent-as  Display routes with inconsistent AS Paths
  multicast        Address family modifier
  neighbors        Detailed information on TCP and BGP neighbor connections
  paths            Path information
  prefix-list      Display routes matching the prefix-list
  quote-regexp     Display routes matching the AS path "regular expression"
  regexp           Display routes matching the AS path regular expression
  route-map        Display routes matching the route-map
  scan             BGP scan status
  summary          Summary of BGP neighbor status
  unicast          Address family modifier
  view             BGP view
  vrf              VRF instance
  |                Output modifiers
  >                Output redirection
  >>               Output redirection (append)
  <cr>
```

```
awplus#show ip bgp vrf <name> ?
  A.B.C.D           IP prefix <network>, e.g., 35.0.0.0
  A.B.C.D/M         IP prefix <network>/<length>, e.g., 35.0.0.0/8
  cidr-only         Display only routes with non-natural netmasks
  community         Display routes matching the communities
  community-list    Display routes matching the community-list
  dampening         BGP Specific commands
  filter-list       Display routes conforming to the filter-list
  inconsistent-as   Display routes with inconsistent AS Paths
  neighbors        Detailed information on TCP and BGP neighbor connections
  prefix-list       Display routes matching the prefix-list
  quote-regexp     Display routes matching the AS path "regular expression"
  regexp            Display routes matching the AS path regular expression
  route-map         Display routes matching the route-map
  summary           Summary of BGP neighbor status
  |                 Output modifiers
  >                 Output redirection
  >>                Output redirection (append)
  <cr>

awplus#show ip bgp x.x.x.x
```

ARP

```
awplus#show arp
 IP Address      MAC Address   Interface    Port      Type

[VRF: <VRFnameA>]
 IP Address      MAC Address   Interface    Port      Type

[VRF: <VRFname B>]
 IP Address      MAC Address   Interface    Port      Type

[VRF: <VRFnameC>]
 IP Address      MAC Address   Interface    Port      Type

awplus#show arp vrf <name>
[VRF: <name>]
 IP Address      MAC Address   Interface    Port      Type
```

HW platform table commands

```
awplus#show platform table ip
awplus#show platform table mac
```

TCPdump

```
awplus#tcpdump ?
  LINE  Execute tcpdump
  vrf   VRF instance
  <cr>

awplus#tcpdump vrf <name> ?
  LINE  Execute tcpdump
```


North America Headquarters | 19800 North Creek Parkway | Suite 100 | Bothell | WA 98011 | USA | T: +1 800 424 4284 | F: +1 425 481 3895
Asia-Pacific Headquarters | 11 Tai Seng Link | Singapore | 534182 | T: +65 6383 3832 | F: +65 6383 3830
EMEA & CSA Operations | Incheonweg 7 | 1437 EK Rozenburg | The Netherlands | T: +31 20 7950020 | F: +31 20 7950021

alliedtelesis.com

C613-16164-00 REV E